Certificate of Mailing/Transmission (37 CFR 1.8a)
I hereby certify that this correspondence, is on the date shown below being

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DATE: _____ Signature _____

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the application of Earl Grim

Serial No.: 10/800,527

Filed: March 15, 2004

Docket No.: 98150C.PUS

Art Unit: 3711

Examiner: S. L. Blau

FOR: IMPACT POINT DEVELOPMENT FOR GOLF CLUBS

To the Commissioner of Patents and Trademarks:

Sir:

DECLARATION

I, Earl D. Grim, am the inventor of the **IMPACT POINT DEVELOPMENT FOR GOLF CLUBS** subject of the above-identified pending patent application.

I completed this invention in the early part of 1998 (See Exhibit "1");

I authorized the filing of a Provisional Patent Application which was filed on June 1, 1999 and is attached hereto as Exhibit "2".

I hereby declare that all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true; and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Dated at Bordentown, New Jersey, this 22nd day of June, 2005.

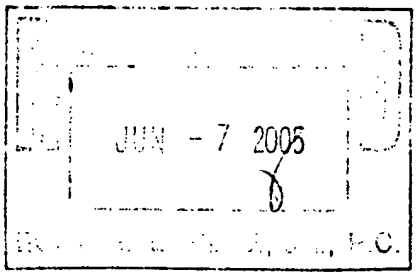
Earl D Grim

EARL D. GRIM

F:\dx90-\98150\Continuation\declarationre1998disclosure.001

renzassoc

From: Grim, Earl D [earl.d.grim@lmco.com]
Sent: Monday, June 06, 2005 2:01 PM
To: gene renz
Subject: 1998 Analyses



Gene:

I found this in my computer hard drive, and will look further at home tonight.

This analysis is dated Feb 1998, and has the basic ideas described. I have changed and upgraded many of the concepts, but the basic ideas are still the same.

Earl

Analysis of the effects of shaft length increases on the ball impact point

Background

This concept for a new approach to club design has been created because of the significant advances in the key components of golf clubs. These advances are primarily in the areas of shaft materials and designs, and in the advances in the materials and designs of the club heads. The club shaft industry has been producing shafts that are continually getting lighter in weight, and yet still providing torque values comparable to steel. Torque is the resistance of the shaft to twisting moments when impacting the ball. Strong shafts are now available that weigh 48 to 69 grams, which is about two ounces. This is about half the weight of a steel shaft. The shafts are also now being designed with large butt diameters, which allow lighter weight wrap grips to be used. This allows another 35 to 40 grams of weight to be removed, which is about another ounce and a half saved over prior club designs.

Club head materials are also evolving, with the advent of the use of titanium, which is lighter and yet as strong as steel. This has led to the design of club heads, especially wood heads, with larger volumes. These heads are dimensionally larger than the classic persimmon and early stainless steel heads, while still preserving the head weight of the earlier designs. There has also been a move towards use of composite materials, such as combinations of titanium and stainless, titanium and aluminum, and recently to ceramic/metal combinations for wood heads, and also for iron heads. This is due in some part to try to beat the increased expense for titanium heads, which has raised the price of clubs dramatically over the past several years. The state of the art in driver head design is now a head which has a volume of 250 to 350 cc, and yet still weighs about 200 grams.

All these developments have led to the major clubmakers selling drivers that are now 45 inches in length, versus the old standard of 43 inches. This length increase has been achieved with a club weight decrease of about two or more ounces. This has been touted as the way for all golfers to increase their length off the tee, which is a key selling point. In order to keep the ball flight under control with these longer clubs, the designers have played with the parameters of the heads, i.e., loft, and weight distributions, and with the flex points of the shaft designs. However, as I will show in the following analysis, the control of the impact point on the club face with longer clubs has not been adequately addressed, and is still a major problem for most golfers. I have studied this problem, and have evolved a solution which I will describe below. This will be based on varying a fundamental parameter of the club design, the lie angle, and modifying the club head design to optimize sweet spot hits.

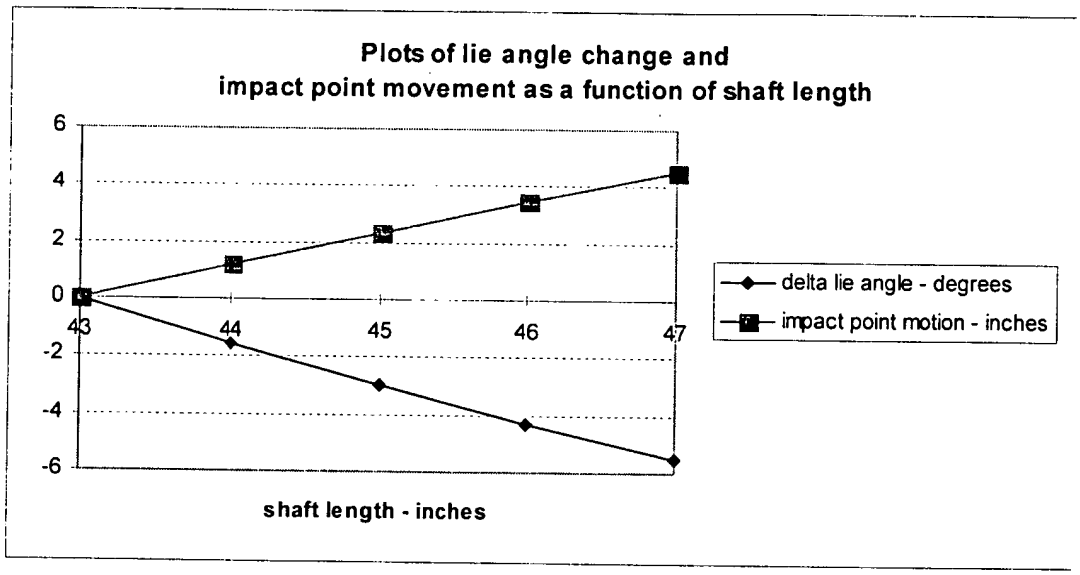
Approach

I first saw the phenomena that led me to this analysis and conclusion on the face of an oversized titanium driver that I had been using earlier this year. I saw a wear pattern that clearly showed me that the impact point on the club face was moving on a path that was perpendicular to the club shaft. This was further verified when I got the February 1998 Golfsmith clubmaker's magazine with the results of a test of the effect of shaft length on the impact point for the golf ball. My analysis and the conclusions I have reached are described below.

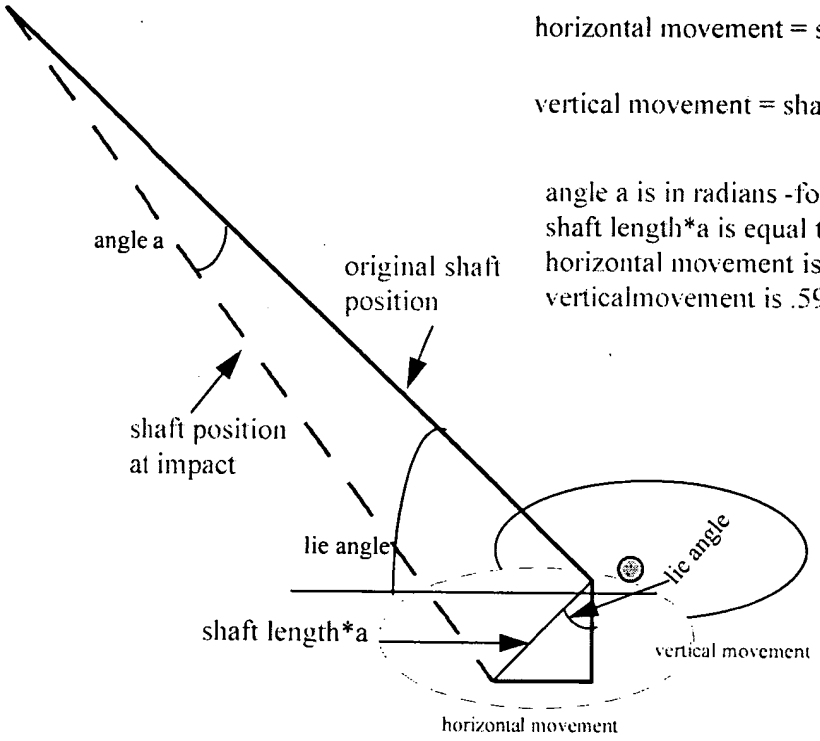
To try to define analytically what is occurring, I analyzed the deviation angle and the offset point motion for various shaft lengths. My assumption here is that any golfer's hands remain at the same height for any shaft length, since he has a fixed height and arm length. Since the golfer takes essentially the same stance each time, his hands remain at the same height. This in turn keeps the butt height of the club shaft at the same height for any length shaft.

This then forces the clubhead to be placed further from the golfer as the shaft length increases, and sets the club down with a flatter lie. This is shown in the first graph to be about 1.5 to 1.25 degrees flatter lie for each inch of added shaft length.

If the golfer has grooved his swing with the lie of a shorter club, his hands will tend to return to that comfortable lie angle with the longer club shaft. This will force a rotation of the shaft downward so that the more comfortable upright lie the golfer is used to is achieved. The angle change is so small that the golfer cannot perceive it. However, the net result of this rotation is to move the shaft and clubface down and in closer to the golfer. This effect is shown below in the second graph. This causes the impact point of the ball to go out and higher on the face. This effect was measured and deviation angles and impact points plotted for shaft lengths varying from 43 to 47 inches in the data shown in the diagrams following. The offset distance perpendicular to the shaft associated with the angle change is shown to be about 1.2 inches for each inch change in shaft length. This can cause the impact point to move above the top of the face in some cases as shown in the following diagrams.



Effects of changes in lie angle on impact point



horizontal movement = shaft length *a*sin(lie angle)

vertical movement = shaft length*a*cos(lie angle)

angle a is in radians -for driver, if a is 1.3 degrees, shaft length*a is equal to 1 inch, and if lie is 55 deg, horizontal movement is .8 inch, verticalmovement is .59 inch

The green circle is the position of the ball, which does not change. At address it is on the face of the original club position, but at impact, it is near the top of the clubface. This effect is shown in the test results for impact point variation with club shaft length which are described below.

Another explanation of this effect follows: The movement of the clubhead downward and in toward the golfer is explained by assuming that the shaft bows down during the downswing. The lie angle is estimated to increase by 1 to 4 degrees during the downward portion of the swing. It is more apparent in the long irons and woods than the short irons. Further information on this can be obtained at the following internet address:

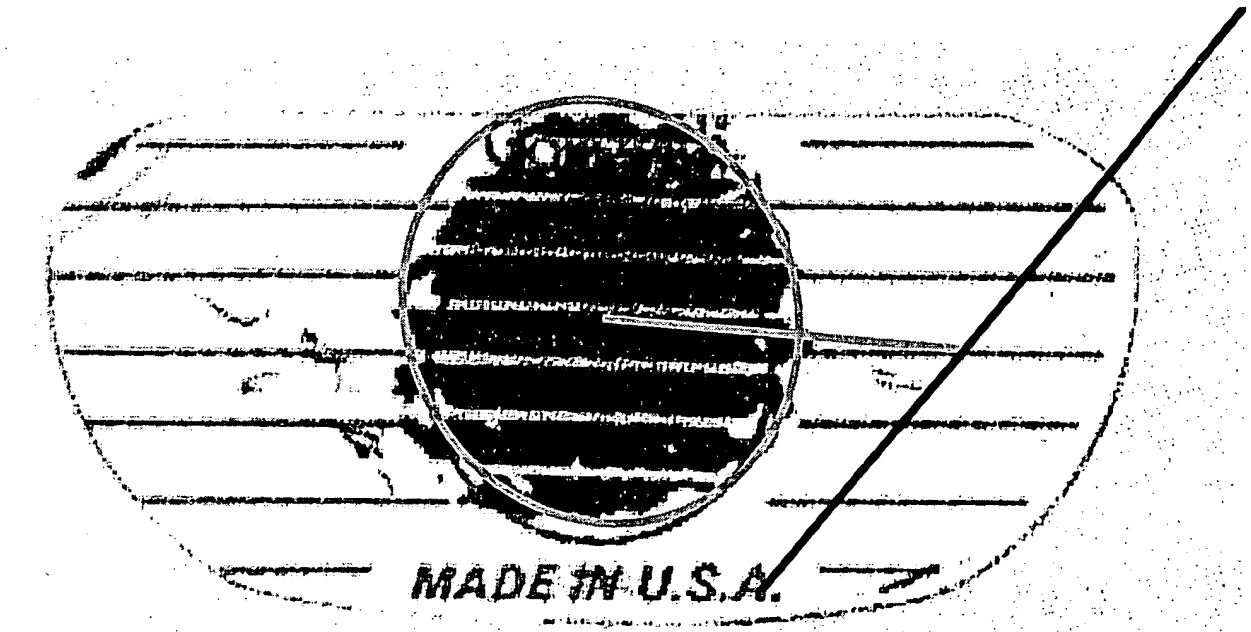
http://www.californiagolfcompany.com/

This bowing effect will occur somewhere between the grip end and the hosel end of the shaft. If the bend is assumed to start at the midpoint of the shaft; on a 45 inch driver, a 4 degrees bow would cause a

displacement of 1.6 inches at the head. This is severe enough to move the impact point off the top of the face as shown in the above diagram.

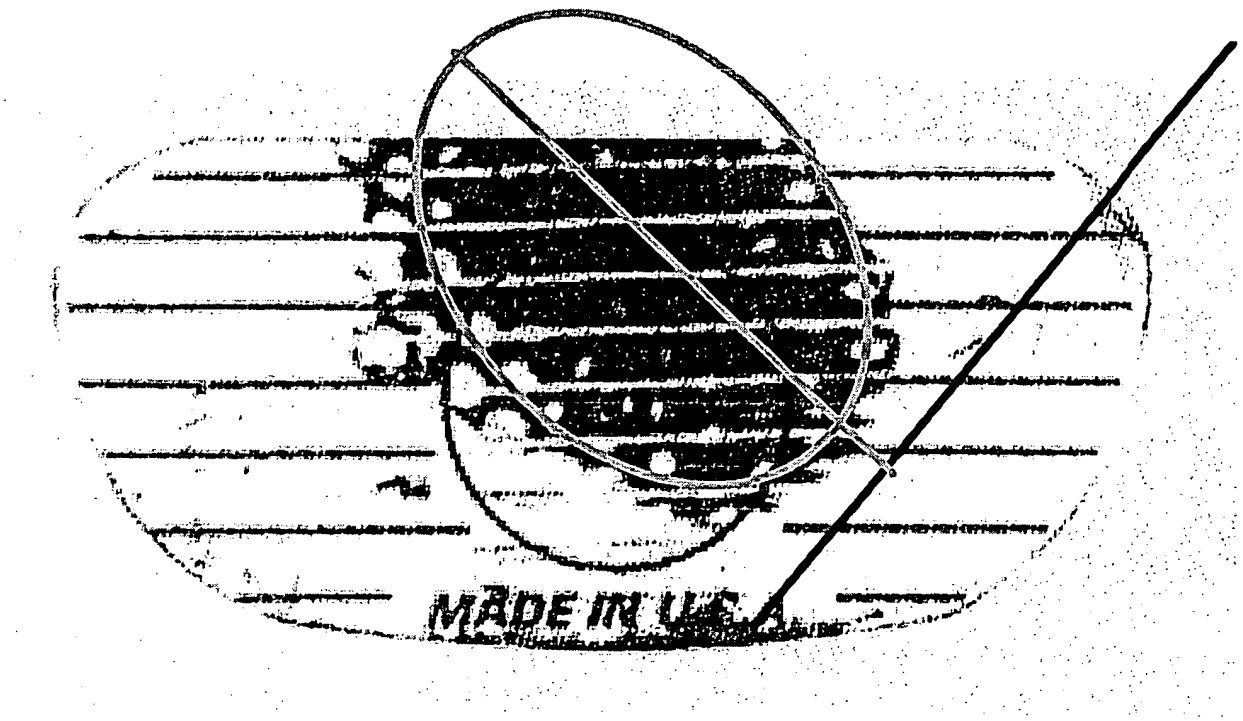
The bottom line is that both explanations show the same effect, which will be corrected by the design concepts described in this paper.

In the plots on the following pages, the 43 inch driver shows an excellent dispersion, with all impacts being centered slightly above the clubface center. In the other plots, the motion of the clubface down and in is clearly shown, with an ellipse around the dispersion, and a locus of points drawn through the center line of the ellipse. This locus is perpendicular to the shaft in all cases. This demonstrates the analysis described above. Plots for 43, 44 and 45 inch shaft lengths are shown following.



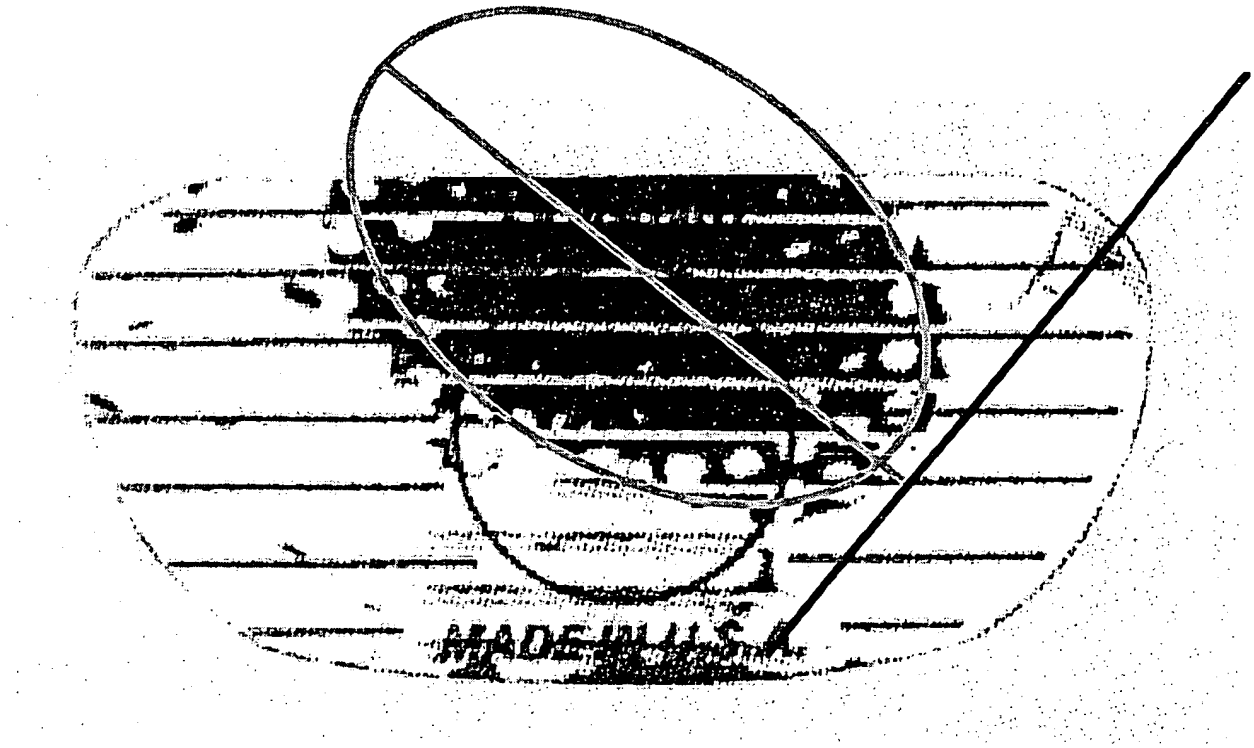
43 Inch Driver

The dispersion for the 43 inch shaft is shown to be excellent, with the center of the ellipse being slightly above the center of the face. The golfer is a low handicapper, and is clearly comfortable with this club length. The lie angle is plotted at 55 degrees, which is a mean value for drivers.



44 Inch Driver

The ellipse here shows that some of the impacts moved off the top of the clubface. The motion of the clubhead is perpendicular to the shaft and carries the head down and in towards the golfer, moving the impact point out and up on the face.



45 Inch Driver

The impact points here are more dispersed and show more tendency to move off the top of the head. The pattern of the motion perpendicular to the shaft is consistent with the results at 44 inches. The same is true for the 46 and 47 inch shaft lengths, with dispersions getting larger.

An approach to provide more consistent ball striking for the longer clubs is shown in the attached pages. The variable that will have maximum beneficial effect if changed is the lie angle. If this is raised about 10 degrees or more, then the impact point locus perpendicular to the shaft will be moved down towards the face centerline, rather than moving off the top of the club as seen in the above clubs. Thus when the longer club tends to come down and in toward the golfer, the impact point will move out on the center of the face, rather than off the top of the face. This will take advantage of the peripheral weightings of the new clubs, and maximize the chances of getting a good shot, even with an off center hit. Additionally, the club heads can be designed with a radiused sole, so that the lie angle can be set comfortably by the golfer. If material is removed from the heel area of the sole, it can be added to the top of the clubhead in the toe area. This will optimize the mass distribution around the impact point locus perpendicular to the shaft. The effect of the upright lie causing the ball trajectory to be to the left for a right handed golfer is not large in a driver with a 9 or 10 degree loft. It is estimated to be 1.6 degrees for a 10 degree loft and 10 degrees upright shaft. This can be corrected by designing a slightly open face, or used as an aid to a golfer who fades or slices the ball.

The value of this design concept is to make it possible for longer lighter clubs to be more forgiving if hit off the sweet spot. The design will tend to keep the locus of impact points of the ball more on the centerline of the face, and help to keep the ball in play. Of course, if the ball is struck in the center of the face on the sweet spot, it does not matter what the configuration is. But even Hogan only hit 3 or 4 perfect shots per round...

Earl D. Grim
February 1998

PTO-103P
(Rev. 6-99) **PROVISIONAL APPLICATION FILING RECEIPT**

CORRECTED

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
ASSISTANT SECRETARY AND COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

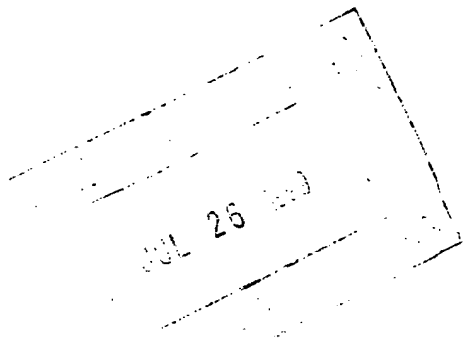
APPLICATION NUMBER	FILING DATE	GRP ART UNIT	FIL FEE REC'D	ATTORNEY DOCKET NO.	DRWGS	TOT CL	IND CL
60/136,968	06/01/99		$200.00	98150P.PUS	0		

EUGENE E RENZ JR PC
205 NORTH MONROE STREET
PO BOX 2056
MEDIA PA 19063-9056

Receipt is acknowledged of this Provisional Application. This Provisional Application will not be examined for patentability. Be sure to provide the PROVISIONAL APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION when inquiring about this application. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please write to the Office of Initial Patent Examination's Customer Service Center. Please provide a copy of this Provisional Application Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts of Application" ("Missing Parts Notice") in this application, please submit any corrections to this Filing Receipt with your reply to the "Missing Parts Notice." When the PTO processes the reply to the "Missing Parts Notice," the PTO will generate another Filing Receipt incorporating the requested corrections (if appropriate). This Provisional Application will automatically be abandoned twelve (12) months after its filing date and will not be subject to revival to restore it to pending status beyond a date which is after twelve (12) months from its filing date.

Applicant(s) EARL GRIM, BORDENTOWN, NJ.

IF REQUIRED, FOREIGN FILING LICENSE GRANTED 06/21/99 ** SMALL ENTITY **
TITLE
ANALYSIS FOR THE NEW GOLF CLUB DESIGN



DATA ENTRY BY: WALKER, PARTHENIA TEAM: 06 DATE: 07/21/99

(See reverse for new important information)

I hereby certify that these papers are being deposited with the United States Postal Service on this date June 1, 1999 in an envelope as "**Express Mail Post Office to Addressee**" service under 37 CFR 1.10, Mailing Label Number EL 007 895 286 US addressed to the: Commissioner of Patents and Trademarks, Washington, DC 20231.

Eugene E. Renz, Jr., Esq.
Name of person mailing paper

Signature of person mailing paper

PROVISIONAL APPLICATION COVER SHEET

DOCKET NO.: **98150P.PUS**

This is a request for filing a PROVISIONAL APPLICATION under 37 CFR 1.53(b)(2)

INVENTOR(S)/APPLICANT(S)					
LAST NAME	FIRST NAME	M.	RESIDENCE (CITY AND EITHER STATE OR FOREIGN COUNTRY		
GRIM	**EARL**		432 FARNSWORTH AVENUE BORDENTOWN, NEW JERSEY 08505		
TITLE OF THE INVENTION (280 characters maximum)					
IMPACT POINT DEVELOPMENT FOR GOLF CLUBS					
CORRESPONDENCE ADDRESS					
Eugene E. Renz, Jr. Eugene E. Renz, Jr., P.C. 205 North Monroe Street P.O. Box 2056					
STATE	Pennsylvania	ZIP CODE	19063-9056	COUNTRY	U.S.A.
ENCLOSED APPLICATION PARTS (*check all that apply*)					
☒ Specification *Number of Pages* 42			☒ Small Entity Status is claimed		
☐ Drawings *Number of Sheets* 0			☐ Other (*specify*) _____		
METHOD OF PAYMENT (*check one*)					
☐ A check or money order is enclosed to cover the Provisional filing fees ☐ The Commissioner is hereby authorized to charge filing fees and credit Deposit Account Number: 18-0990			PROVISIONAL FILING FEE AMOUNT (S)		**$75.00**

The invention was made by an agency of the U.S. Government or under a contract with an agency of the U.S. Government.

☒ No.

☐ Yes, the names of the U.S. Government Agency and the Government contract number are:

Respectfully submitted,

SIGNATURE _____ Date June 1, 1999

PRINTED NAME **EUGENE E. RENZ, JR.** Registration No.: 19,557 *(if appropriate)*

☐ *Additional inventors are being named on a separate numbered sheets attached hereto*

ANALYSIS FOR THE NEW GOLF CLUB DESIGN

The diagrams below show the basis for the new club design concepts. A right handed driver is used in the diagrams. Data was obtained showing the dispersion of hits on the club face as the length of the club was increased.

This shows a consistent result with the impacts being contained in an area which was estimated by an ellipse. The key point observed was that the centerline of this ellipse is perpendicular to the shaft centerline. In the following diagrams, the driver length is 45 inches, which is two inches longer than the standard 43 inch driver length. It is observed that this length is becoming standard for the new lightweight titanium graphite driver designs.

The miss pattern indicates that the 45 inch club is harder to control, and the head tends to moves down and in towards the golfer, on an arc perpendicular to the club shaft. The miss pattern indicates that the club shaft has rotated down about 3 to 4 degrees around a center at the butt end of the shaft. This result is consistent. It can be explained by several theories:

1.due to centrifugal force tending to straighten out the angle between the golfers arms and the club shaft, or

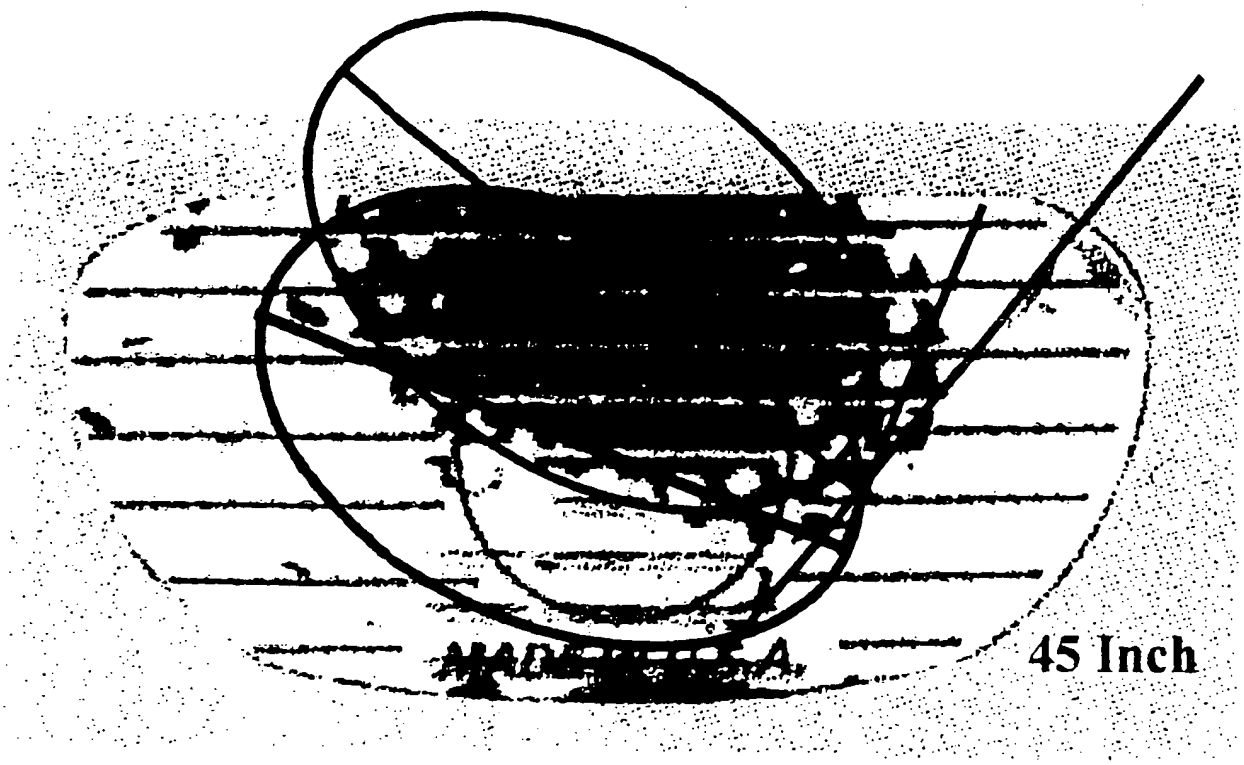
2. to the fact that the longer length of the club makes the set up lie angle flatter for the golfer than for the 43 inch driver.

As the golfer swings, the club tends to return to the setup lie angle that he would have taken with a shorter driver. For a two inch length increase, this angle is 3 degrees, which correlates to the observed data.

In any event, the results are consistent, and some means to correct these miss errors is needed. An analysis and proposed solution are presented below. This idea has been prototyped, and has been successful in improving the quality of driver shots for a range of golfers from scratch to 20 handicaps.

This first diagram shows the impact data in black, the approximating ellipse and its centerline in blue, and the same ellipse rotated so as to stay on the face in purple. The new shaft angle to accomplish this rotation is also shown in purple.

Several drivers have been modified to demonstrate this approach and have been successful in Improving driver performance.



The red line shows the standard shaft lie angle – about 55 degrees

The miss impact area is shown by the black patterns.

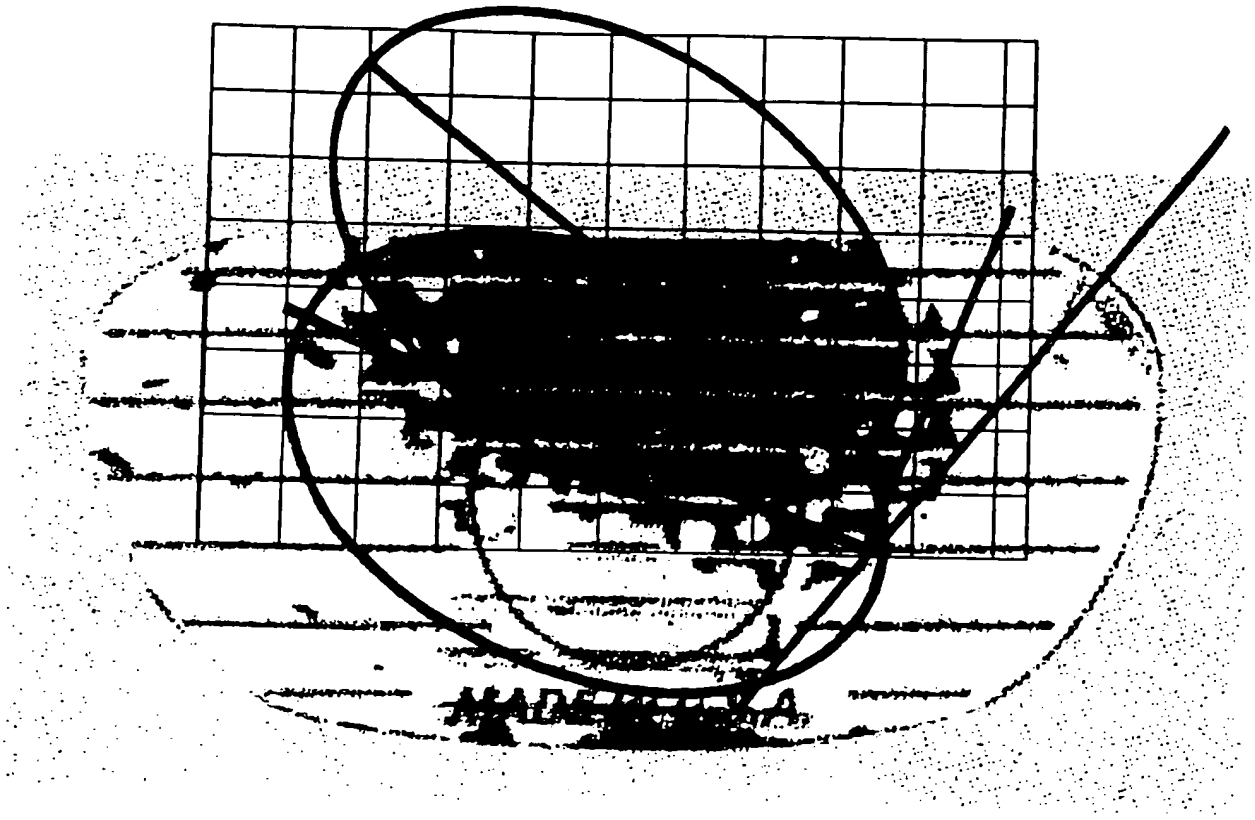
The miss area is represented by a blue ellipse. The centerline of this ellipse is shown, and it is ***perpendicular to the shaft centerline***

The new shaft angle is derived from the new ellipse location. It is perpendicular to the centerline of the new miss ellipse

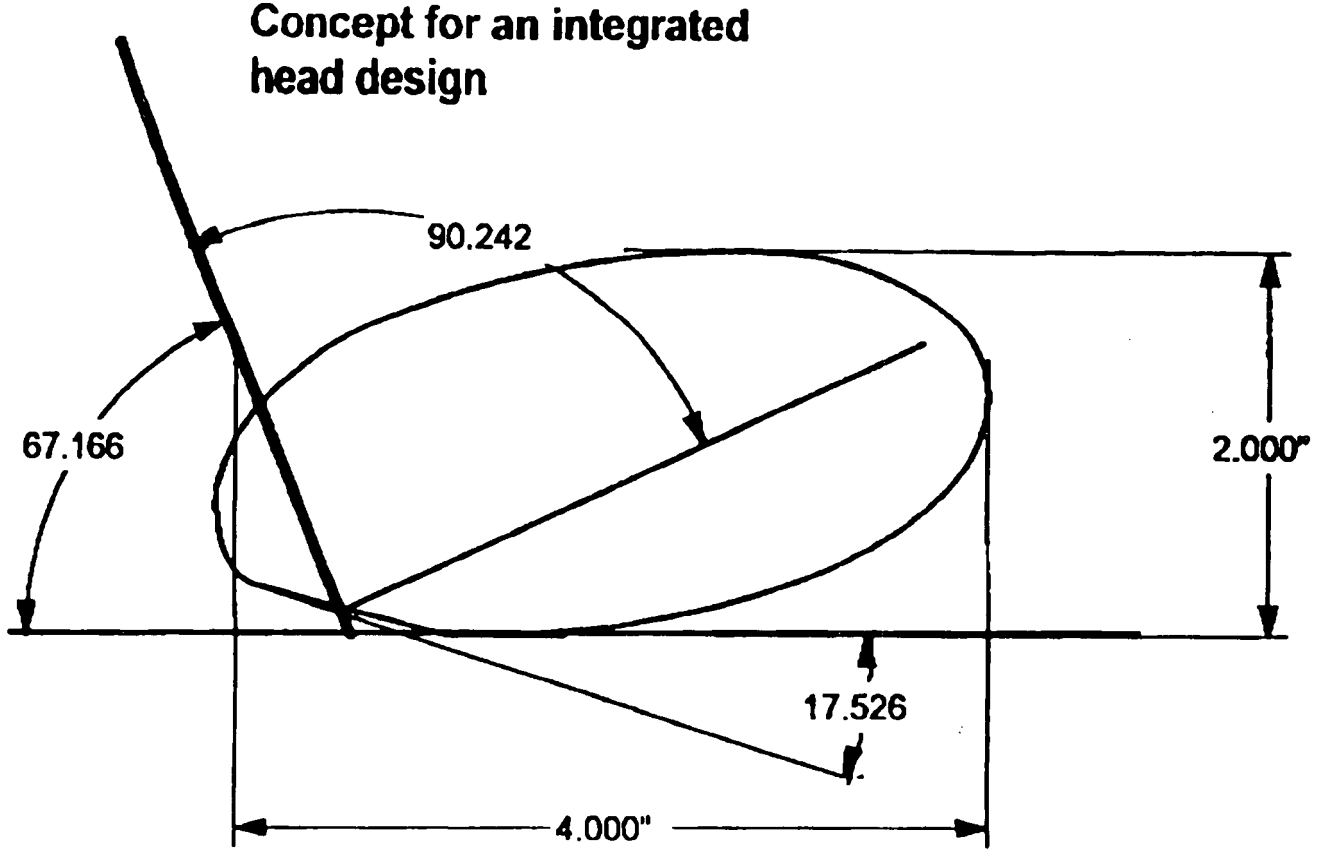
The original club design and lie angle led to hits off the top of the face, causing skyed, fat shots. These shots will now be hit on the face of the club, since the motion of the club will be perpendicular to the shaft centerline. This new design will yield greatly improved shots with the new club design. since now the misses will be within the miss ellipse, which is now on the club face. The effectiveness of this approach has been demonstrated with several prototype clubs.

An analysis of the prediction for effectiveness for the new approach for the alignment of the shaft and impact ellipse is shown below.

The grid shows that there is about 15/(15+22) or about 40% of the misses off the face. The new geometry with the more upright lie angle brings these misses onto the face. This will improve the 40% missed shots made with conventional head designs.

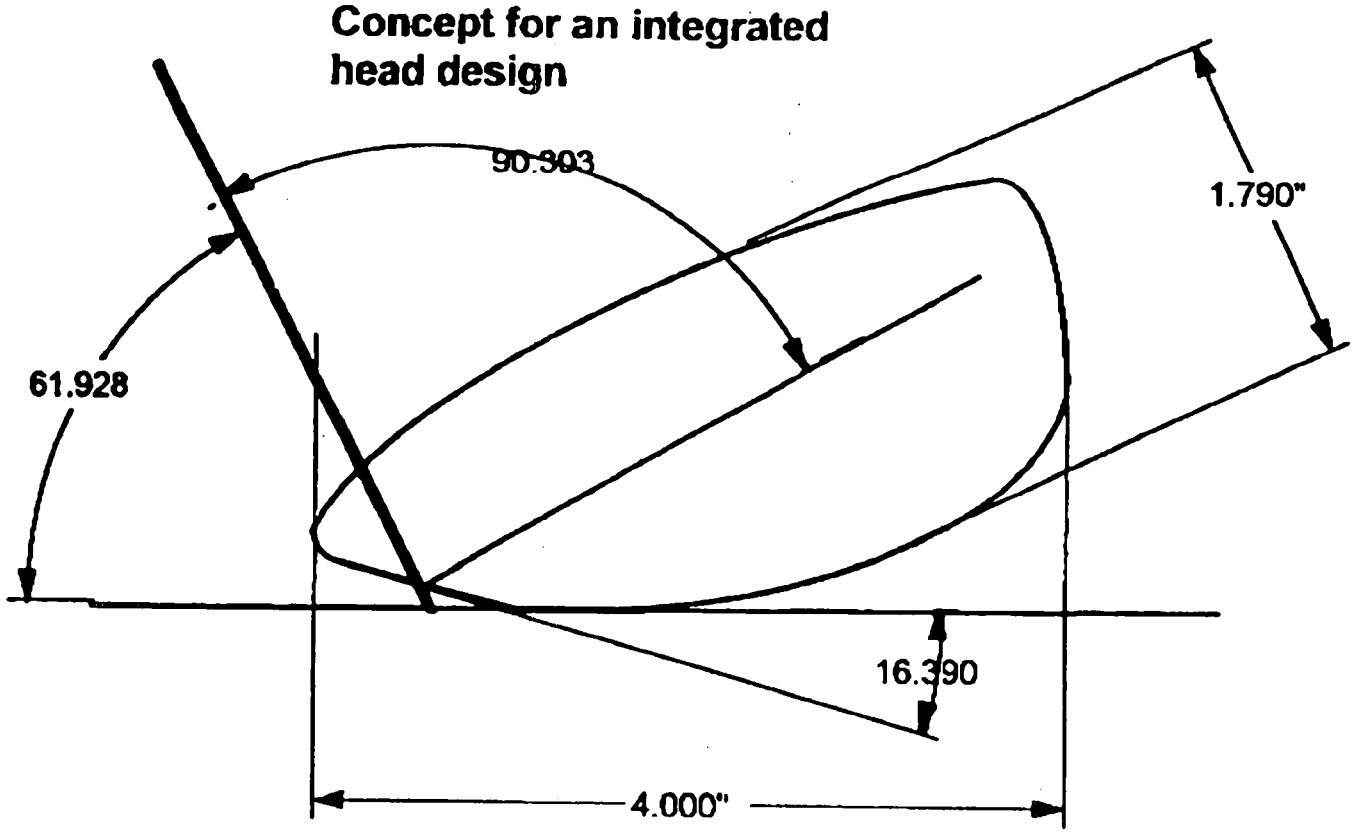


45 Inch



Key considerations here are the following:

* The locus of points perpendicular to the shaft need to lie on or near the centerline of the face. The head design should reflect the best of the present designs that maximize the moment of inertia of the head.
*This then determines the lie angle of the shaft This concept shows a lie angle of about 67 degrees based on this approach
*The heel of the sole of the club needs to be angled or radiused such that the club can be comfortable set down at lie angles as low as 50 degrees or less This is shown in the diagram
*The material removed from the bottom of the sole should then be added to the toe area on the top of the head. This optimizes the moment of inertia for this club design approach
*Head dimensions are conceptual. They will be modified as the club head design progresses.



this head configuration has a flatter topline, and as indicated, would require about a 62 degree lie angle. This would result in the line normal to the shaft to stay on the club face It would pass very close to the centerpoint of the face

If the face scoring lines are made perpendicular to the shaft, then they will highlight the locus of points on the impact distribution ellipse center line. This could be a trademark of this club design, i.e.; a toe high, highly forgiving club to swing. Especially forgiving when using a long shaft and the resulting tendency for the club head to come down and in towards the golfer

Analysis of the design of a golf club to optimize trajectory characteristics

Background

This concept for a new approach to club design has been created because of the significant advances in design of the key components of golf clubs. These advances are primarily in the areas of shaft materials and designs, and in the advances in the materials and designs of the club heads. The club shaft industry has been producing shafts that are continually getting lighter in weight, and yet still providing torque values comparable to steel. Torque is the resistance of the shaft to twisting moments when impacting the ball. Strong shafts are now available that weigh 48 to 69 grams, which is about two ounces. This is about half the weight of a steel shaft. The shafts are also now being designed with large butt diameters, which allow lighter weight wrap grips to be used. This allows another 35 to 40 grams of weight to be removed, which is about another ounce and a half saved over prior club designs.

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All these developments have led to the major clubmakers selling drivers that are now 45 inches in length, versus the old standard of 43 inches. This length increase has been achieved with a club weight decrease of about 1 or more ounces. This has been touted as the way for all golfers to increase their length off the tee which is a key selling point. In order to keep the ball flight under control with these longer clubs, the designers have played with the parameters of the heads, i.e., loft, and weight distributions, and the kick points of the shaft designs. However, as I will show in the following analysis, the control of the impact point on the club face with longer clubs has not been adequately addressed, and is still a major problem for most golfers. I have studied this problem, and have evolved a solution which I will describe below. This will be based on varying a fundamental parameter of the club design, the lie angle, and modifying the club head design to optimize sweet spot hits.

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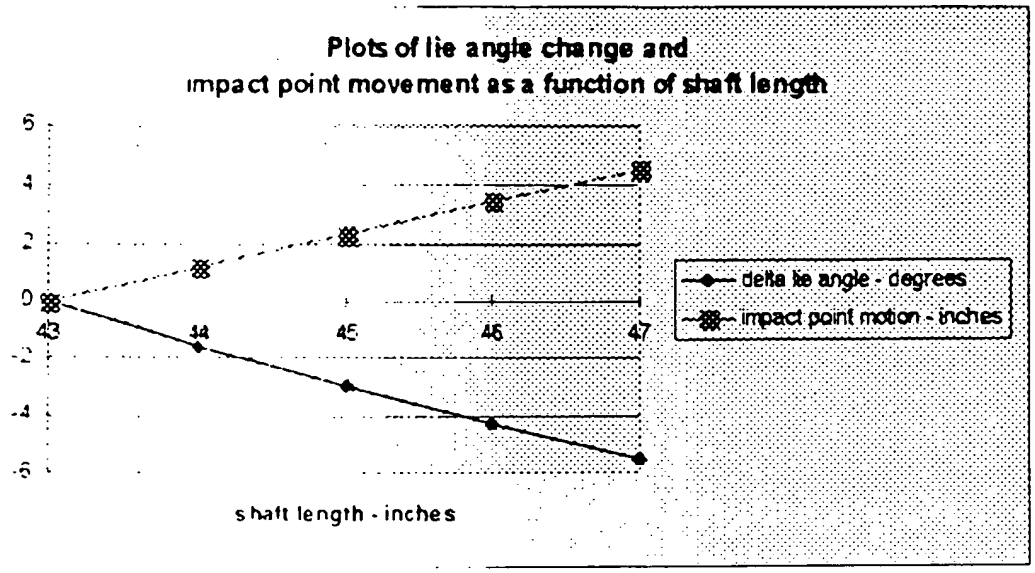
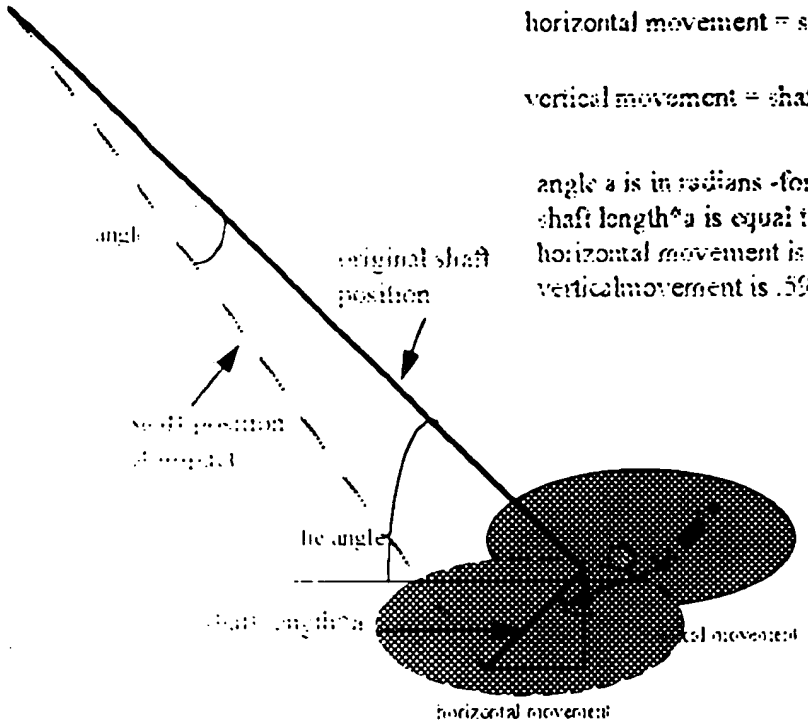


Effects of changes in lie angle on impact point



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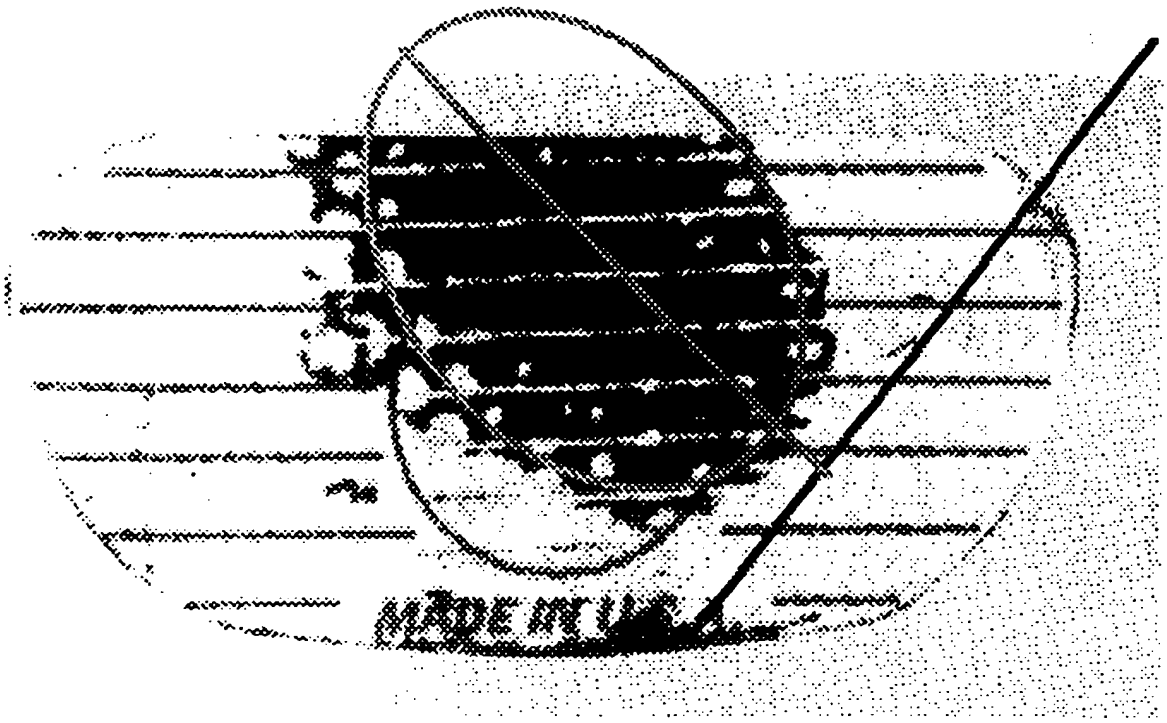
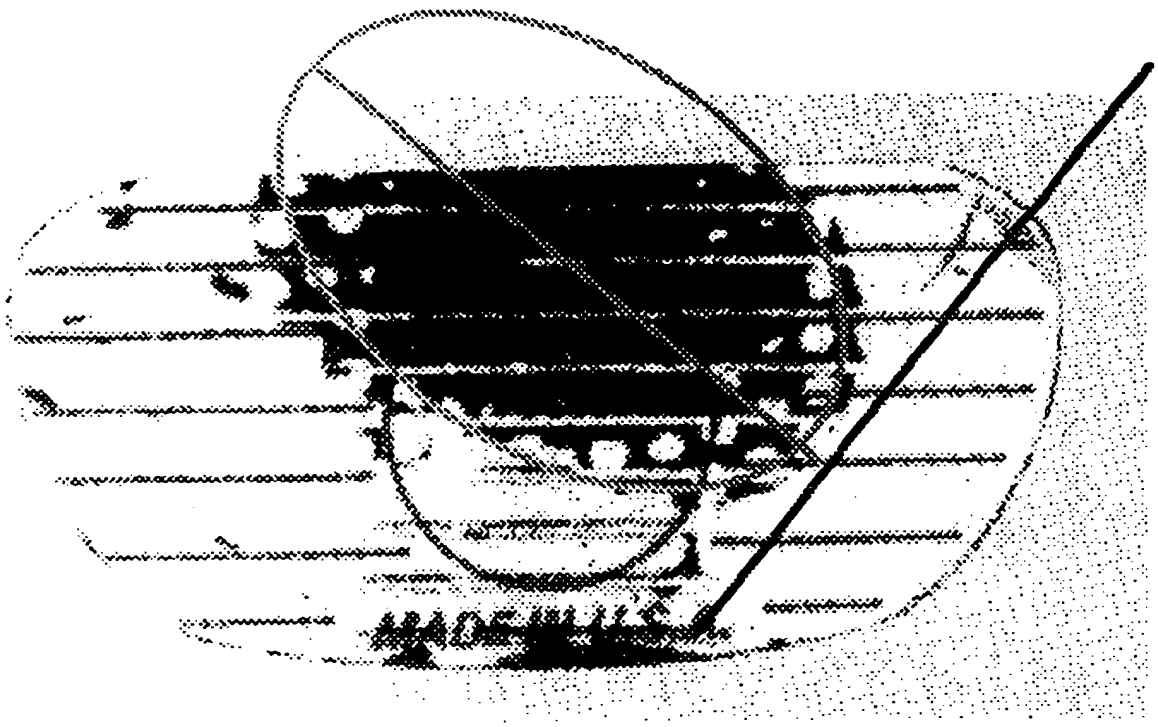
43 Inch Driver

The dispersion for the 43 inch shaft is shown to be excellent, with the center of the ellipse being slightly above the center of the face. The golfer is a low handicapper, and is clearly comfortable with this club length. The lie angle is plotted at 55 degrees, which is a mean value for drivers.



44 Inch Driver

The ellipse here shows that some of the impacts moved off the top of the clubface in the case of the 44 inch driver shaft length. The motion of the clubhead is perpendicular to the shaft and carries the head down and in towards the golfer, moving the impact point out and up on the face, as was asserted in the above analysis



45 Inch Driver

The impact points here for a 45 inch shaft are more dispersed and show more tendency to move off the top of the head. The pattern of the motion perpendicular to the shaft is consistent with the results at 44 inches. The same is true for the 46 and 47 inch shaft lengths, with dispersions getting larger.

An approach to provide more consistent ball striking for the longer clubs is shown in the attached pages. The two variables that will have maximum beneficial effect if changed are the lie angle, and the weight distribution in the club head. If the lie angle is raised about 10 degrees or more, then the impact point locus perpendicular to the shaft will be rotated down to pass through the face sweet spot, rather than moving off the top of the club as seen in the above Golfsmith plots. Thus when the longer club tends to come down and across the golfer, the impact point will move out through the center of the face, rather than off the top of the face. If this is combined with the proper weight distribution in the head design, and take advantage of the proper peripheral weighting, it will maximize the chances of getting a good shot, even with an off center hit. Additionally, the club heads can be designed with a radiused sole, so that the lie angle can be set conveniently by the golfer. With this design, material removed from the heel area of the sole can be added to the top of the clubhead in the toe area. This will optimize the mass distribution around the impact point locus perpendicular to the shaft.

If the three dimensional geometry of the ball trajectory coming off the above club face is analyzed, it can be seen that the upright lie that will result from the club design will cause the ball trajectory for a right handed golfer to go to the left of target, or conversely, for a left handed golfer to go to the right. The effect of the upright lie causing the ball trajectory to be offset is not large in a driver with a 9 or 10 degree loft. It is estimated to be 1 to 2 degrees for a 10 degree face loft and 10 degrees upright shaft. This can be corrected by designing a slightly open face, e.g. 1 degree, or used as an aid to a golfer who fades or slices the ball. This effect is relatively small for upright lofted clubs, e.g., woods and long irons. It can

become more pronounced in higher lofted clubs, but since these are already have more upright lies, this design concept could still be applied with progressively smaller increases in lie angle.

The value of this design concept is to make it possible for longer lighter clubs to be more forgiving if hit off the sweet spot. The design will tend to keep the locus of impact points of the ball more on the sweetspot of the face and help to keep the ball in play. Of course, if the ball is struck in the center of the face on the sweet spot it does not matter what the configuration is. But even Hogan only hit 3 or 4 perfect shots per round

Earl D. Grim
February 1998

First cut claims for originality

1. This teaches a new approach to the integrated design of a golf club.

2. This approach for an integrated design of a golf club head is based upon the observation of the dispersion of impact points on the face of my personal set of clubs, and on the data obtained from the February 1998 issue of Golfsmith Clubmaker magazine. These data showed that the dispersion of the locus of points of the centerline of the ball impact ellipse is perpendicular to the club shaft.

3. On this basis the designer will first design the golf club head with a weight distribution that is low in the heel and high in the toe of this head. The locus of the centerline of the impact ellipse is postulated to be from the low heel position to the high toe position, passing through the sweet spot impact area.

4. Then the hosel lie angle will be defined such that the shaft centerline is perpendicular to the centerline of the impact ellipse defined above

5. This design approach will result in an upright lie angle for most woods and long irons.

6. However this is not a problem for any golfer that uses the club, no matter what his/her height and stance to the ball

7. This is due to the fact that no matter how the golfer addresses the ball, the locus of the impact ellipse is fixed and remains perpendicular to the shaft and on the face of the club.

8. This will improve the performance of the club and the golfer for the inevitable shots he/she hits off the sweet spot

9. Improvement is anticipated to be optimum in the longer irons and woods.

10. Length increases for lighter club designs are automatically compensated for by the concepts described in 5-7 above

11. This is the club automatically compensates for any lie angle variations due to the physical configuration of the golfer and eliminates the need for any adjustments to be made to the club in a fitting process

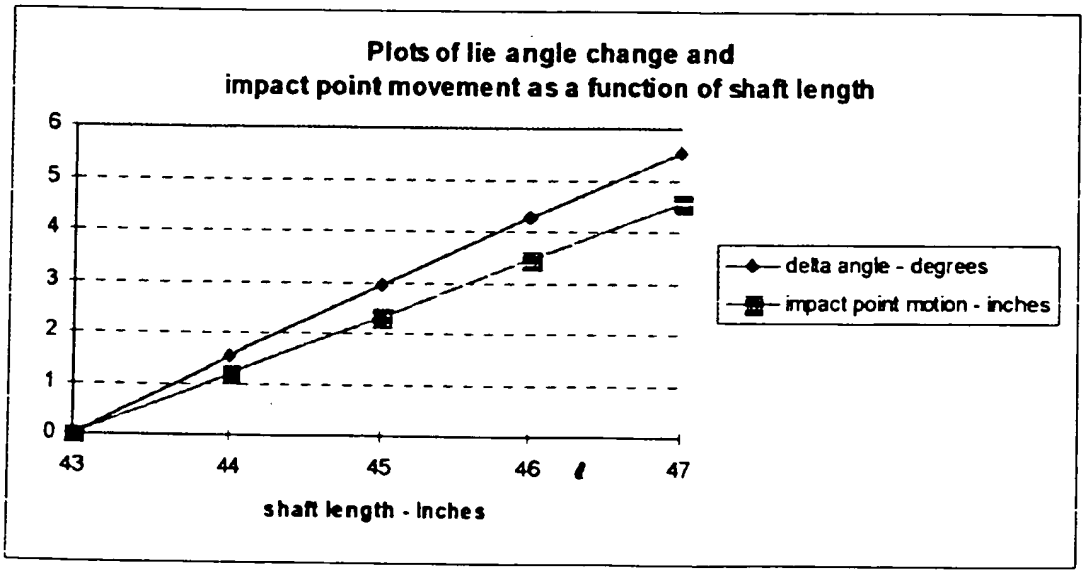
Analysis of th. .ffects of shaft length increases on the ball impact point

I first saw the phenomena that led me to this analysis and conclusion in the face of an oversized titanium driver that I had been using earlier this year. I saw a wear pattern that clearly showed me that the impact point on the club face was moving on a path that was perpendicular to the club shaft. This has not been seen by any of the club designers, and was clearly a significant observation. This was further verified when I got the Golfsmith clubmaker's magazine with the results of a test of the effect of shaft length on the impact point for the golf ball. My analysis and the conclusions I have reached are described below.

To try to define analytically what is occurring, I analyzed the deviation angle and the offset point motion for various shaft lengths. My assumption here is that any golfer's hands remain at the same height for any shaft length, since he has a fixed height and arm length. Since the golfer takes essentially the same stance each time, his hands remain at the same height. This in turn keeps the butt height of the club shaft at the same height for any length shaft.

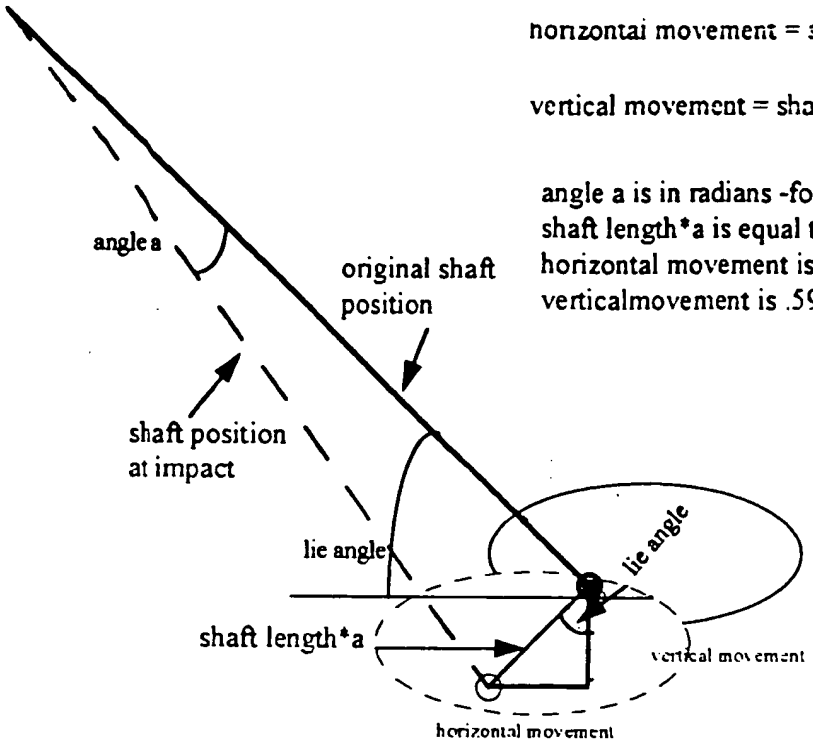
This then forces the clubhead to be placed further from the golfer as the shaft length increases, and sets the club down with a flatter lie. This is shown in the following graph to be about 1.5 to 1.25 degrees flatter lie for each inch of added shaft length.

If the golfer has been comfortable with the lie of a shorter club, his hands will tend to return to that comfortable lie angle with the longer club shaft. This will force a rotation of the shaft downward so that the more comfortable upright lie the golfer is used to is achieved. The angle change is so small that the golfer cannot perceive it. However, the net result of this rotation is to move the shaft and clubface down and in closer to the golfer. A graphic of this effect is shown on the following page. This causes the impact point of the ball to go out and higher on the face. This effect was measured and deviation angles and impact points plotted for shaft lengths varying from 43 to 47 inches in the data shown in the diagrams following. The offset distance perpendicular to the shaft associated with the angle change is shown to be about 1.2 inches for each inch change in shaft length. This can cause the impact point to move above the top of the face in some cases as shown in the following diagrams.



In the plots on the following pages, the 43 inch driver shows an excellent dispersion, with all impacts being centered slightly above the clubface center. In the other plots, the motion of the clubface down and in is clearly shown, with an ellipse around the dispersion, and a locus of points drawn through the center line of the ellipse. This locus is perpendicular to the shaft in all cases. This demonstrates the analysis described above. Plots for 43, 44 and 45 inch shaft lengths are shown on the following pages.

Effects of changes in lie angle on impact point



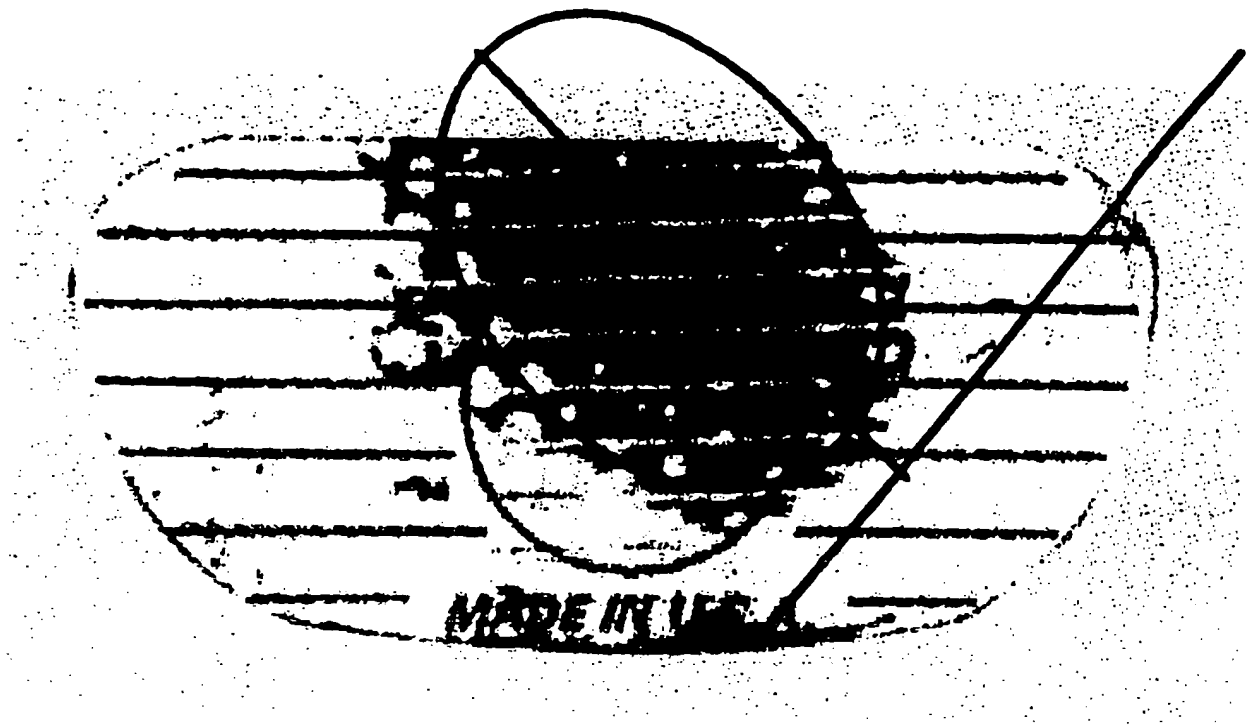
horizontal movement = shaft length *a*sin(lie angle)

vertical movement = shaft length*a*cos(lie angle)

angle a is in radians -for driver, if a is 1.3 degrees, shaft length*a is equal to 1 inch, and if lie is 55 deg. horizontal movement is .8 inch, verticalmovement is .59 inch

43 Inch Driver

The dispersion for the 43 inch shaft is shown to be excellent, with the center of the ellipse being slightly above the center of the face. The golfer is a low handicapper, and is clearly comfortable with this club length. The lie angle is plotted at 55 degrees, which is a mean value for drivers.



44 Inch Driver

The ellipse here shows that some of the impacts moved off the top of the clubface. The motion of the clubhead is perpendicular to the shaft and carries the head down and in towards the golfer, moving the impact point out and up on the face.

45 Inch Driver

The impact points here are more dispersed and show more tendency to move off the top of the head. The pattern of the motion perpendicular to the shaft is consistent with the results at 44 inches. The same is true for the 46 and 47 inch shaft lengths, with dispersions getting larger.

An approach to provide more consistent ball striking for the longer clubs is shown in the attached pages. The single variable that will have maximum beneficial effect if changed is the lie angle of the driver. If this is raised about 10 degrees, then the perpendicular locus from the shaft will be moved down towards the face centerline, rather than moving off the top of the club as seen in the above clubs. Thus when the longer club tends to come down and in toward the golfer, the impact point will move out on the center of the face, rather than off the top of the face. This will take advantage of the peripheral weightings of the new drivers, and maximize the chances of getting a good shot, even with an off center hit.

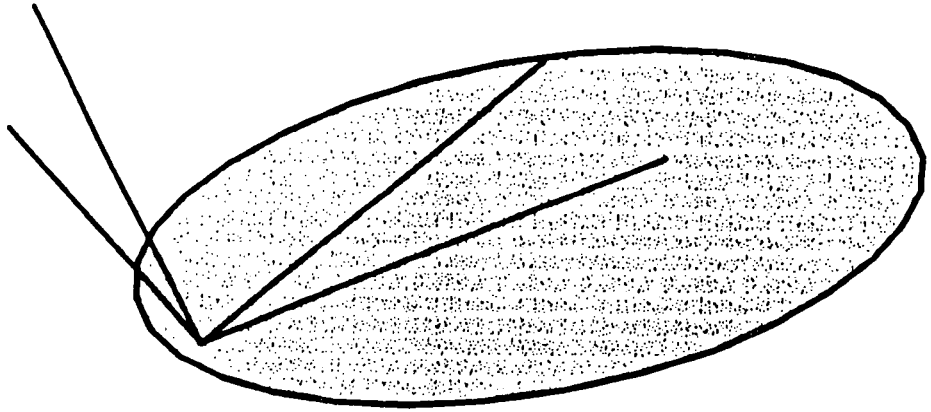
The key point here is that if the ball is struck in the center of the face on the sweet spot, it does not matter what the configuration is. However, if the ball is struck off the sweet spot, and the length of the club is moving the clubface in and down, then the effect of the offset hit is minimized by a driver with a more upright lie.

this shows the idea of raising the lie angle of the driver about 10 degrees. This in turn causes the rotation motion of the longer shaft to move the impact point onto the face of the club, rather than off the top of the face. The red lines show the increased lie and associated locus of impact line, while the black set shows the locus with standard lie.

The only change needed is to cast the driver head with an increased lie angle. Depending on the design of the head, this should be about an increase of 5 to 10 degrees in the lie angle.

I will investigate the cost and schedule to get this mod done to an otherwise standard driver head, and then test out my hypothesis.

he golfer will hold the club with
s normal comfortable lie angle.
With the increased lie of the club
this will raise the toe of the driver,
and bring the face into alignment
with the motion of the clubface
with the longer shaft lengths.



With the radiused sole, there will be no problem with the club being set up with the toe up. If the increased lie angle is between 5 and 10 degrees, then the tilting of the face back towards the golfer will result in a negligible offline angle. At 5 degrees, the offset is about 2.5 yards in 200 yards.

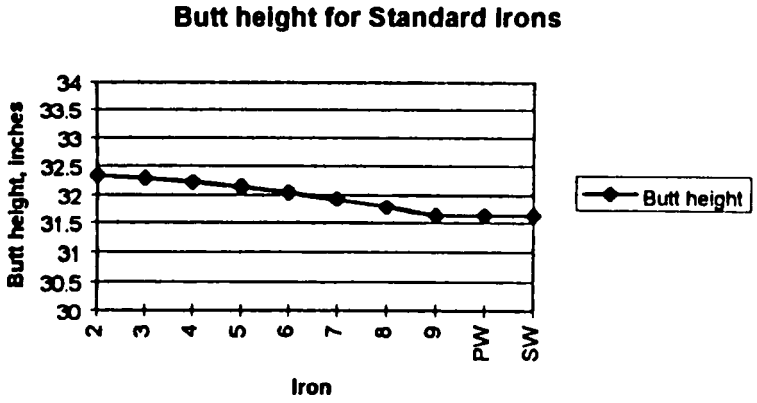
Concepts for a New Golf Club Design

Earl Grim

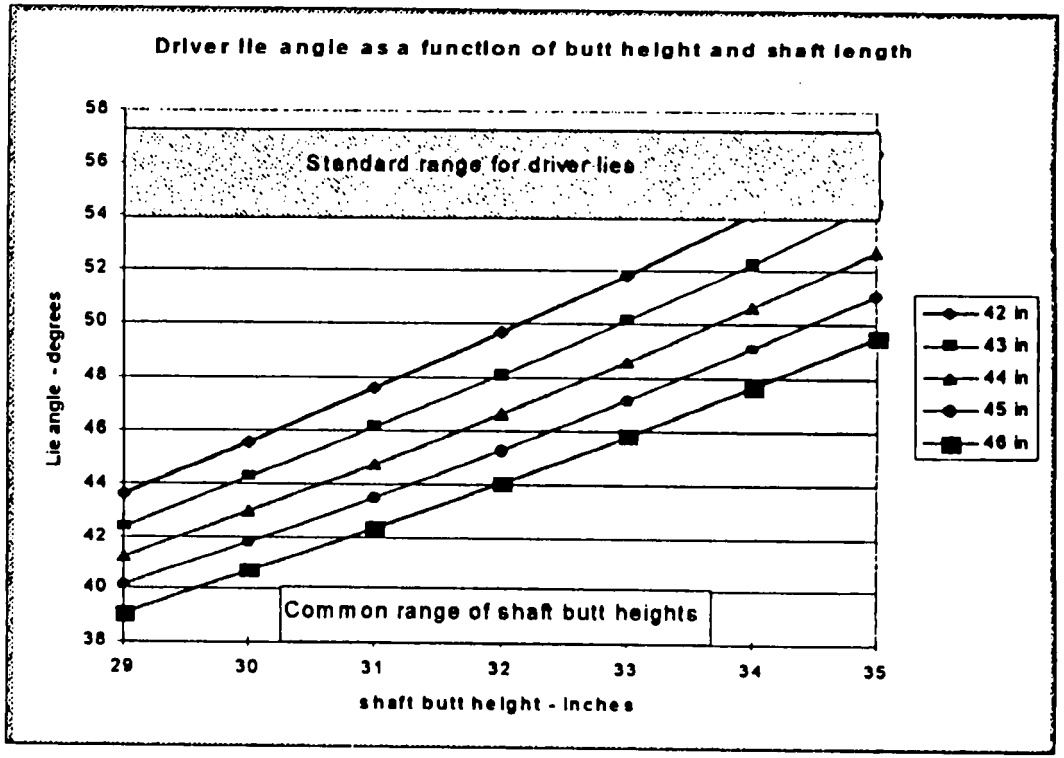
[redacted]

609 298 5899

Preliminary Observations Comparing Standard Clubs to Average Golfers



The standard length and lie of irons match the butt height of the iron shaft to the hand height of the average golfer, which is about 32 inches.



Conversely, the standard length and lie of drivers do not match the requirements for hand height of the average golfer. The standard driver at 43 inches and 56 degree lie is 8 degrees higher than the 48 degree lie required by the standard golfer. This gets worse as the length increases, going up to a 12 degree difference at a 46 inch length.

Further Observations on the Present Day Design of Conventional Drivers

This triangle represents the typical address setup of an average golfer with a 43 inch driver and a hand height that places the butt end of the club 32 inches above the ground, forcing the angle between the club shaft and the ground to about 48 degrees.

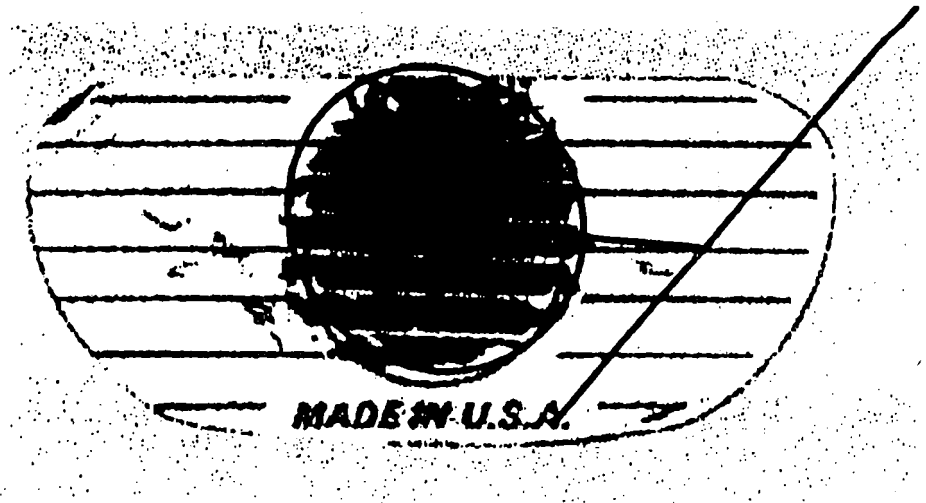
Because the standard lie angle of the driver is about 56 degrees, the driver will sit toe up by about 8 degrees. This is in contrast to the set up angle of irons, which are very well matched to the average golfer.

Why is there such a difference between the fitting of irons compared to the fitting of woods? I contend it is because when the attempt was made to reduce the driver lie angle to 48 degrees or less, the club makers found that it became very difficult to hit this club. They compromised with a higher lie to preserve club performance.

This was optimized for standard length drivers,i.e., 43 inches, but as longer drivers were designed, the problems re-appeared.

I will explain this further below, and show how the club design can be optimized for performance by understanding this effect.

Experimental Result of the Effect of Club Length on Hit Dispersion



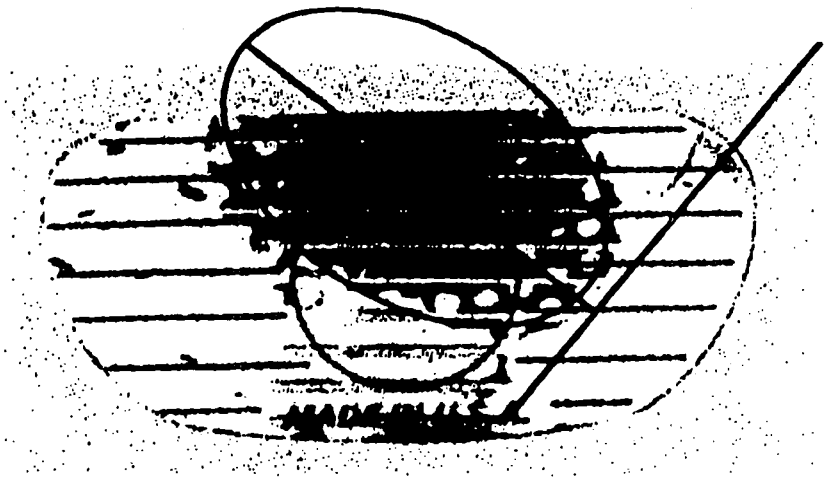
43 Inch Driver

The dispersion for the 43 inch shaft is shown to be excellent, with the center of the ellipse being slightly above the center of the face. The golfer is a low handicapper, and is clearly comfortable with this club length. The lie angle is plotted at 55 degrees, which is a mean value for drivers.

44 Inch Driver

The ellipse here shows that some of the impacts moved off the top of the clubface in the case of the 44 inch driver shaft length. The motion of the club head is perpendicular to the shaft and carries the head down and in towards the golfer, moving the impact point out and up on the face.

Experimental Result of the Effect of Club Length on Hit Dispersion, cont.



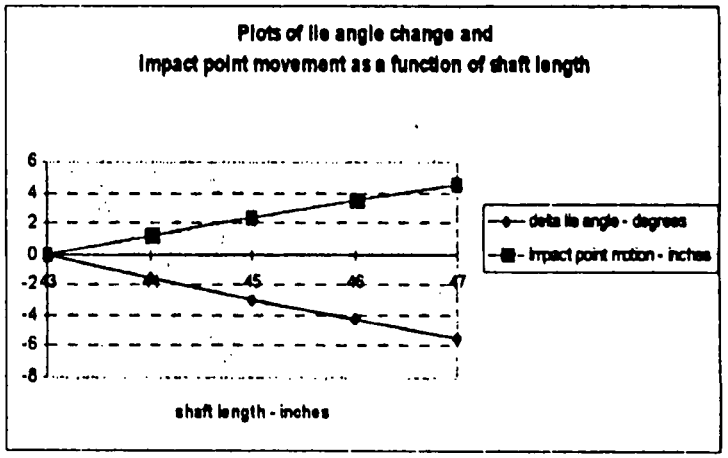
45 Inch Driver

The impact points here for a 45 inch shaft are more dispersed and show more tendency to move off the top of the head. The pattern of the motion perpendicular to the shaft is consistent with the results at 44 inches. The same is true for the 46 and 47 inch shaft lengths, with dispersions getting larger.

The baseline impact data were published in the Feb 1998 issue of the Golfsmith Clubmakers Technical Journal.
The analysis and conclusions were added by E.D. Grim.

The key concepts for the new club design approach

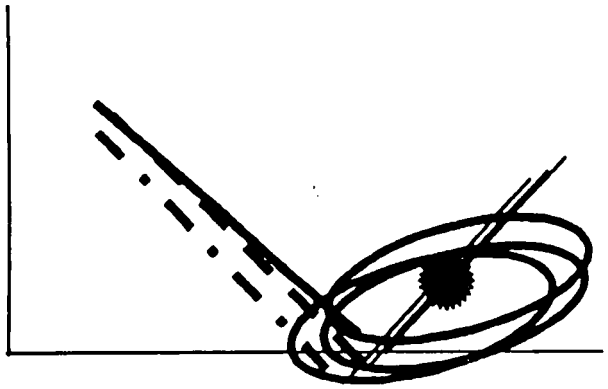
The available data shows the error path taken by the club head as a function of the club shaft length. The key fact shown is that " THE ERRORS IN POSITIONING THE CLUB AT IMPACT ARE DUE TO THE CLUB SHAFT AND HEAD MOVING ON A LINE PERPENDICULAR TO THE CLUB SHAFT CENTER LINE." The net effect of errors in the path of the club head is to hit the shot fat and high in the toe as the swing is made. In present club designs the lie angle is fixed such that the line perpendicular to the centerline of the shaft is not coincident with the centerline of the sweetspot ellipse of the head This will be shown in the following slides. The magnitude of the impact point movement is shown at the right for shaft lengths from 43 to 47 inches. This assumes that the golfer's lie angle is optimum at 43 inches, and with the longer clubs his lie angle returns to the 43 inch value at impact.



To remedy this problem, a new design concept is proposed. In this concept, the club is designed so that the centerline of the sweetspot ellipse of the head is coincident with the line perpendicular to the centerline of the shaft. When this is done, any errors in the swing tend to contain the impact point of the ball within the sweetspot of the head. This will improve the performance of the club, and will counter the errors found in the impact points associated with the designs using longer shaft lengths and preserving conventional lie angles.

This concept will allow the evolution of new club designs to continue, and will support the design of new effective clubs using the breakthrough technology of lighter shafts, oversized heads, and big butt technology. The understanding of how the path of the impact point with respect to the head sweetspot moves is a key concept in this breakthrough approach to head design.

Behavior of Conventional Driver Designs as Club Length Increases



The line shows the error path of the club head. It is along a line perpendicular to the shaft centerline. This path has been observed in face wear patterns and by experiments

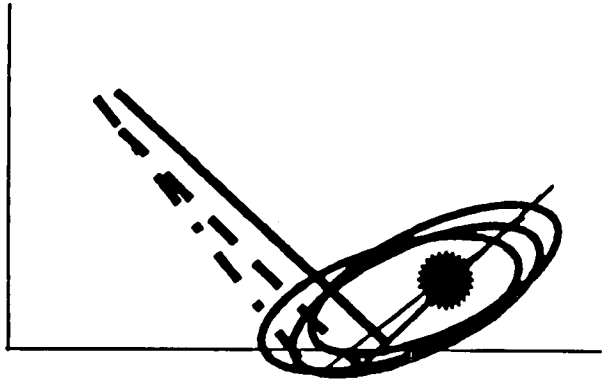
The club is set up to the ball normally. The assumption is made here that the wood has a standard driver lie of 56 degrees, and the golfer is average with a club butt height of 32 inches. Two shaft lengths; 44 and 45 inches will be shown.

With the 44 inch shaft, the club comes through down and in on the error path perpendicular to the shaft centerline; moving the ball impact up on the face, producing a fat shot

With a 45 inch shaft, the head moves more down and in on a path perpendicular to the shaft centerline moving the impact point off the top of the face

An approach to improving club performance and minimizing the effect of club head rotation in the vertical plane is shown on the following slide

Improvement in Performance with the New Design Concept



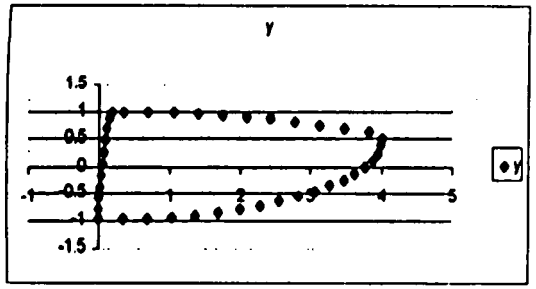
As before, the club is set up to the ball normally. The wood here is designed so that the centerline of the club sweetspot ellipse is perpendicular to the shaft centerline. This is independent of hand height and will be true for any golfer. Two shaft lengths; 44 and 45 inches will be shown.

With the 44 inch shaft, the club comes through down and in on the error path perpendicular to the shaft centerline; however, with this design, the ball impact stays on the face, improving the quality of the shot

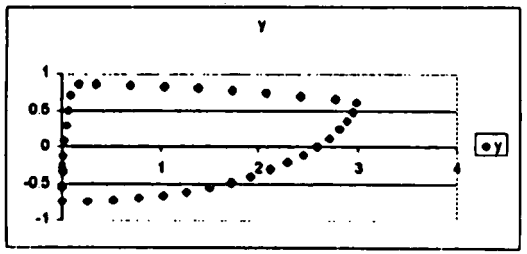
With a 45 inch shaft, the head still moves more down and in on a path perpendicular to the shaft centerline; but the impact point still stays on the hitting area of the face

This new club design concept will improve the quality of the game for all handicap levels, and will match the new longer clubs to all golfers tall or short, large or small..

Concepts for a Long Shaft Wood Head Design to Optimize Performance

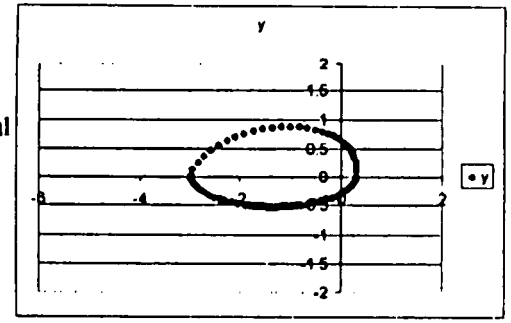


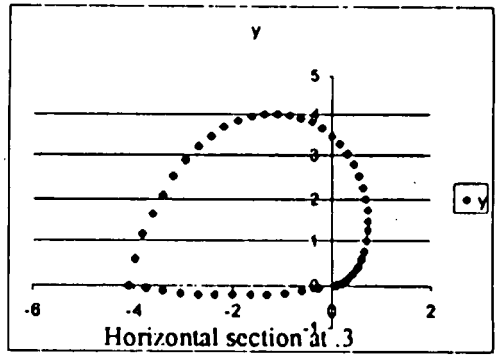
Z section at 1.5



Z section at 3

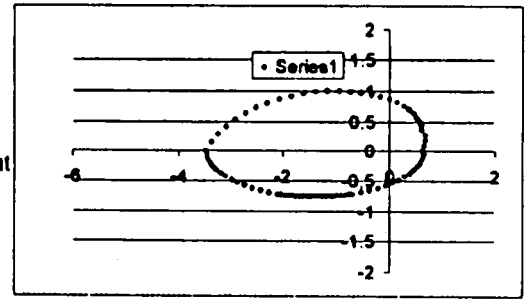
Vertical section at 3

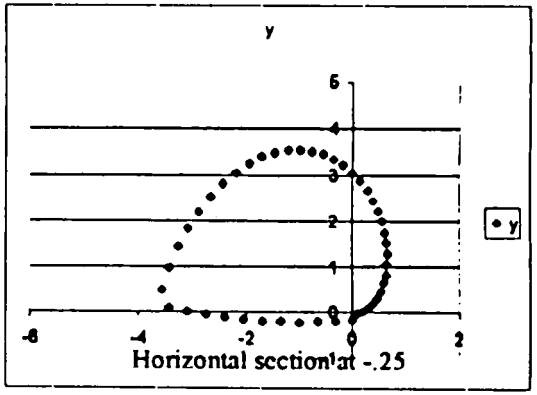




Horizontal section at .3

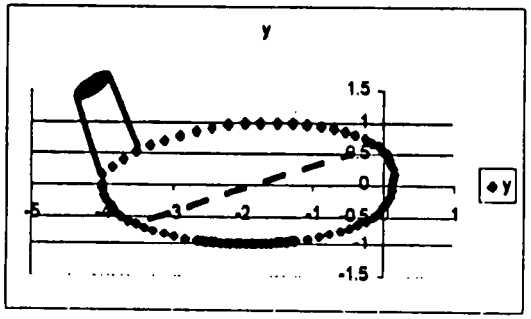
Vertical section at 2

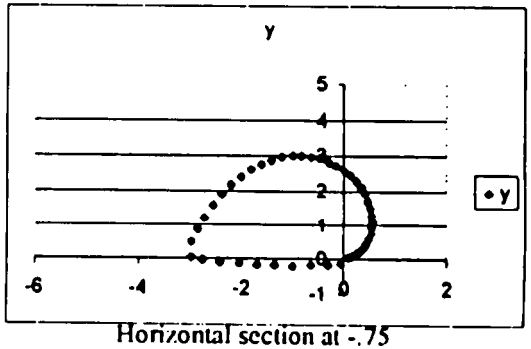




Horizontal section at -.25

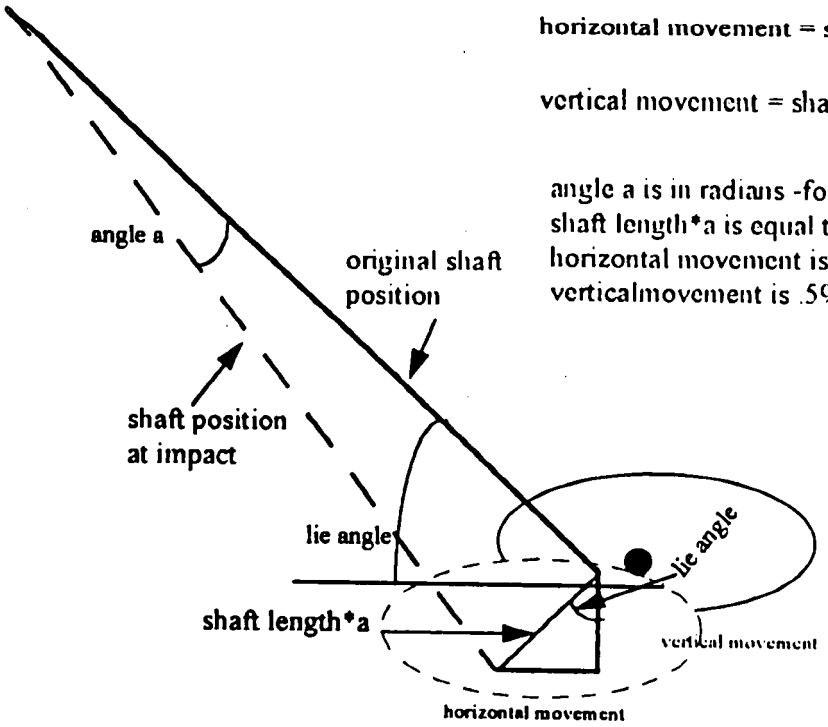
Vertical section at 0





Horizontal section at -.75

Effects of changes in lie angle on impact point



horizontal movement = shaft length *a*sin(lie angle)

vertical movement = shaft length*a*cos(lie angle)

angle a is in radians -for driver, if a is 1.3 degrees, shaft length*a is equal to 1 inch, and if lie is 55 deg, horizontal movement is .8 inch, verticalmovement is .59 inch

Approach to Improve Performance of Longer Lighter Golf Club Woods

The new technology advances in head design and especially in shaft design have made possible the fabrication of longer lighter clubs, especially in the woods. This has been used to market clubs that are claimed to hit the ball further and be easier to use because of their lighter weight.

I have found information and also experienced that this is not universally the case. In general, the lengthening of the shafts of the club have made it harder to hit the ball consistently in the center of the face, and therefore has decreased the distance achievable with these new clubs, rather than improving these characteristics.

In order to enhance the possibilities for improvement in performance due to the technology advances, and minimize the effects of mis-hitting the ball with these new longer clubs, I have created a new approach concept. This is concerned with the design of the club, and the generation of a modified design approach, based on the observations that I have analyzed.

The data taken at Golfsmith on the variation of impact point of the ball on the club face as a function of shaft length shows a consistent and predictable pattern. It is a pattern that I have also seen in my own driver and iron faces, which I have fabricated to be longer and lighter than standard clubs. This pattern can be bounded by an ellipse, with the elongated axis being perpendicular to the centerline of the shaft of the club. This is a consistent effect, seen in the Golfsmith data, and in my own clubs. The impact point moves away from the shaft, and perpendicular to it. With the standard lie angles for the woods, as the club shaft length increases the centerline of the impact ellipse moves off the top of the club face, leading to fat, skyed shots.

Since the standard lie angle for golf clubs has been established from experience, it is observed in the designs of the major club makers. This angle is the angle subtended by a line drawn down the centerline of the shaft, and a horizontal line which is tangent to the sole of the club at the contact point that rests on the ground at address. The standard lie for a driver is 54 degrees. However, it is shown in the following diagrams that this lie angle combined with even standard length woods does not fit the general population. For the majority of the population the butt height of the club lies in the range of 30 to 33 inches. For shorter players and women it can go as low as 28 or 29 inches. The plots show what the actual lie angles will be for driver lengths of 42 to 46 inches for these golfers when they address the ball. This range is from 40 to about 50 degrees. This is compared to the lie angles provided by the manufacturers, which range from 54 to 57 degrees. The question of why the manufacturers have maintained this mis-match between what is required and what is provided in wood lie angles will be discussed further below.

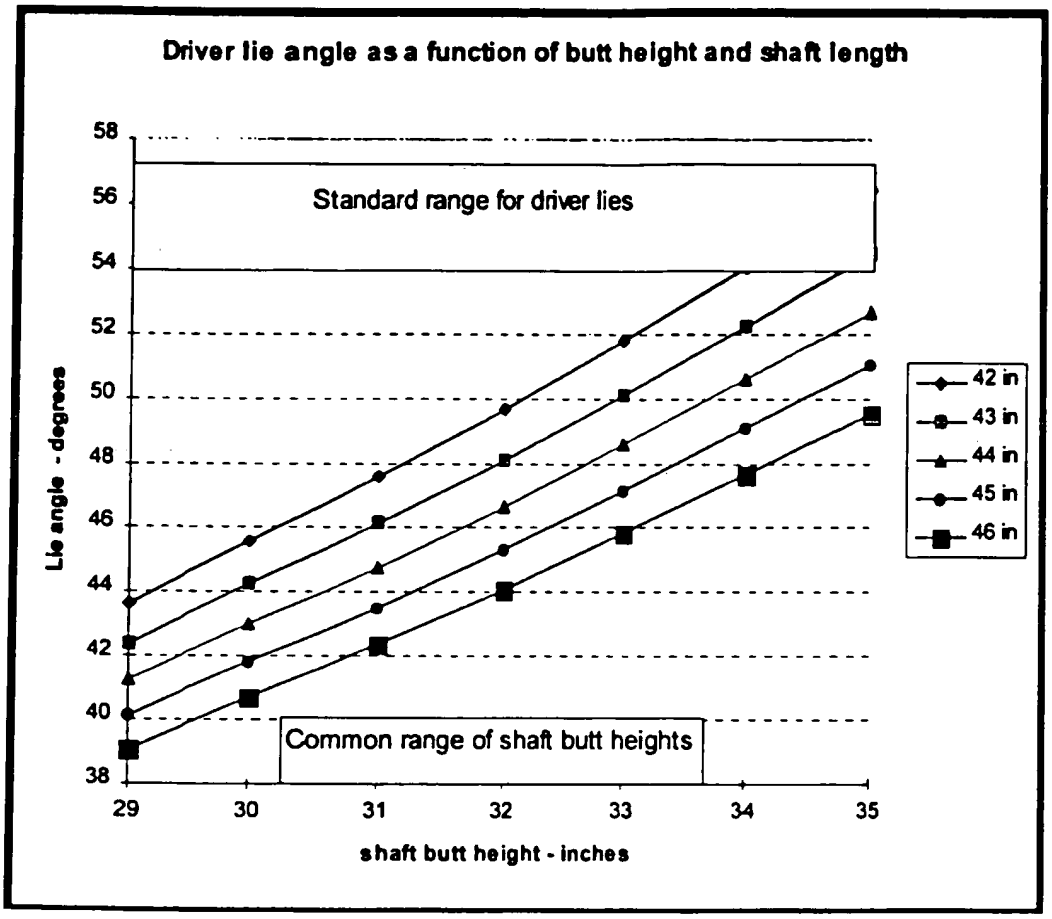
Another plot is of interest in this analysis. This is the plot shown below of the butt height of irons with standard lengths and lies. These butt heights fall in the range of 31.5 to 32.5 inches, which match well the general population. So the match of the lie angles in the irons to the general population is excellent, but is completely out of range in the wood clubs. Why??

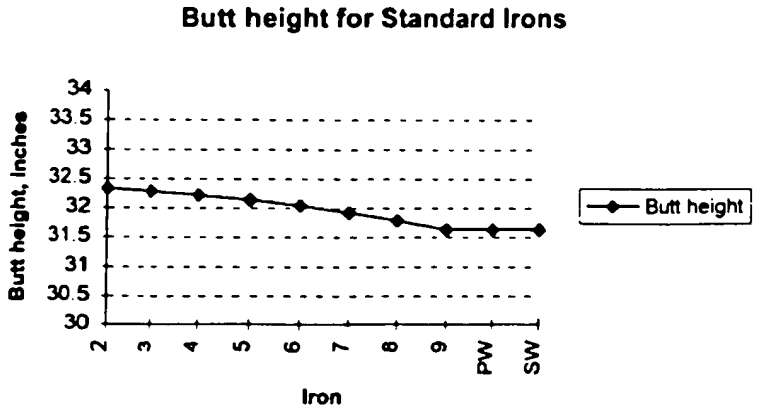
My opinion on this is that it was found that any design for a wood with a lower lie angle did not perform well, and was abandoned by the manufacturers. The fact that performance would be degraded is borne out by my analysis of the movement of the impact ellipse off the face of the club perpendicular to the centerline of the shaft for mis-hit shots. This effect would become worse as the lie angle was decreased.

I will show below that the way to optimize the performance of wood clubs, especially the new longer lighter clubs, is to increase rather than decrease the lie angle of the design, to a value greater than the standard lie.

I have observed that most of the golfers, and especially the woman golfers, address the ball with the driver in a toe-up position. This is the direct result of the standard lie angle being too large for their hand position. In order to provide the best fit to the spectrum of golfer hand heights that occur, the newest

wood club designs have gone to a radiused sole, so that changes in the hand height of the golfer can be compensated at address by rotation of the club shaft either up for taller golfers, or down for shorter golfers. This has been done by the club manufacturers rather than build woods with the lie angles that would set the club head down horizontally to the ball. Either from experience or from adherence to standards, the lie angles for the driver has been preserved at 54 degrees, and with most recent designs, have gone up as high as 57 or 58 degrees for the new longer lighter clubs.

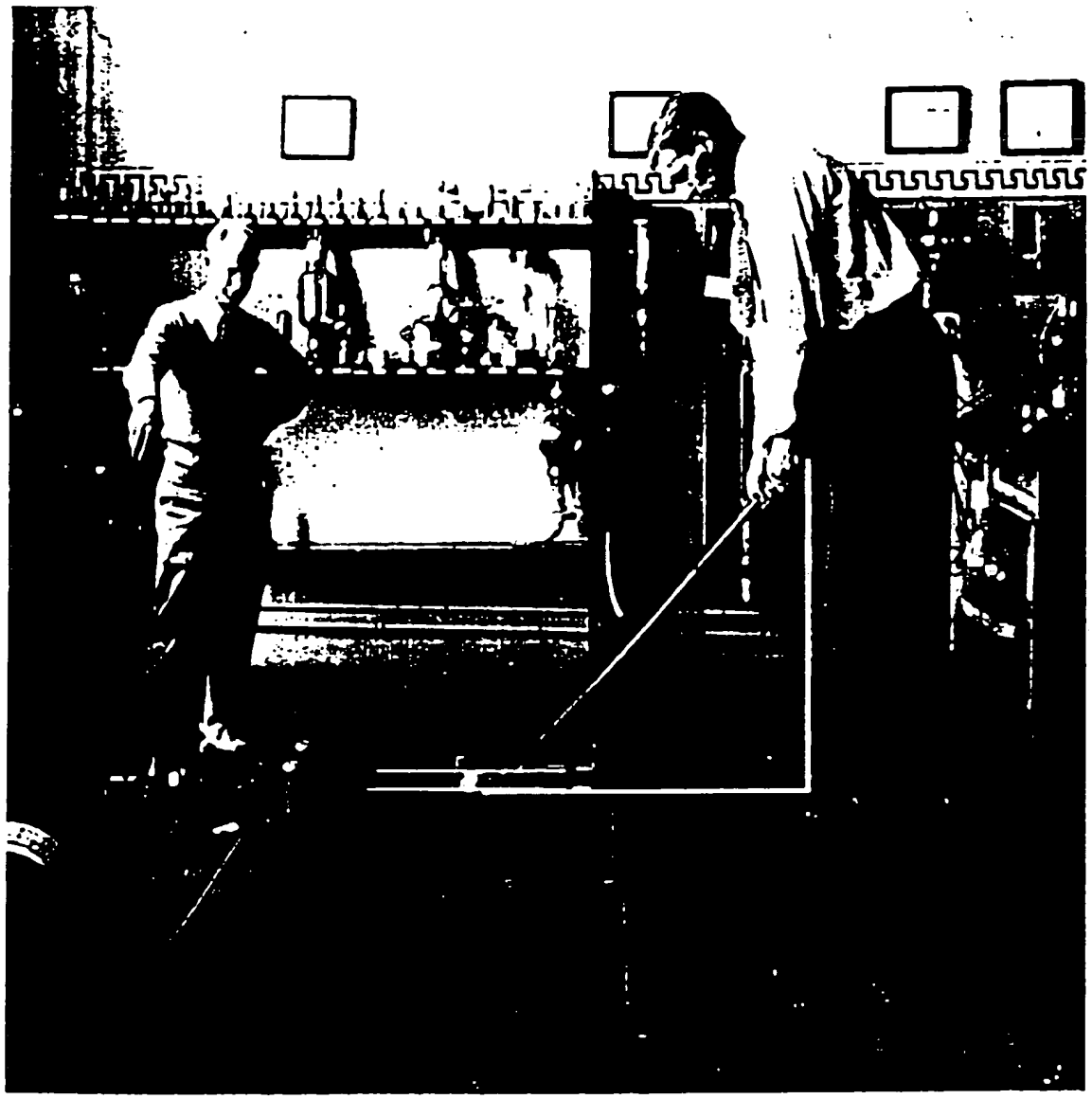




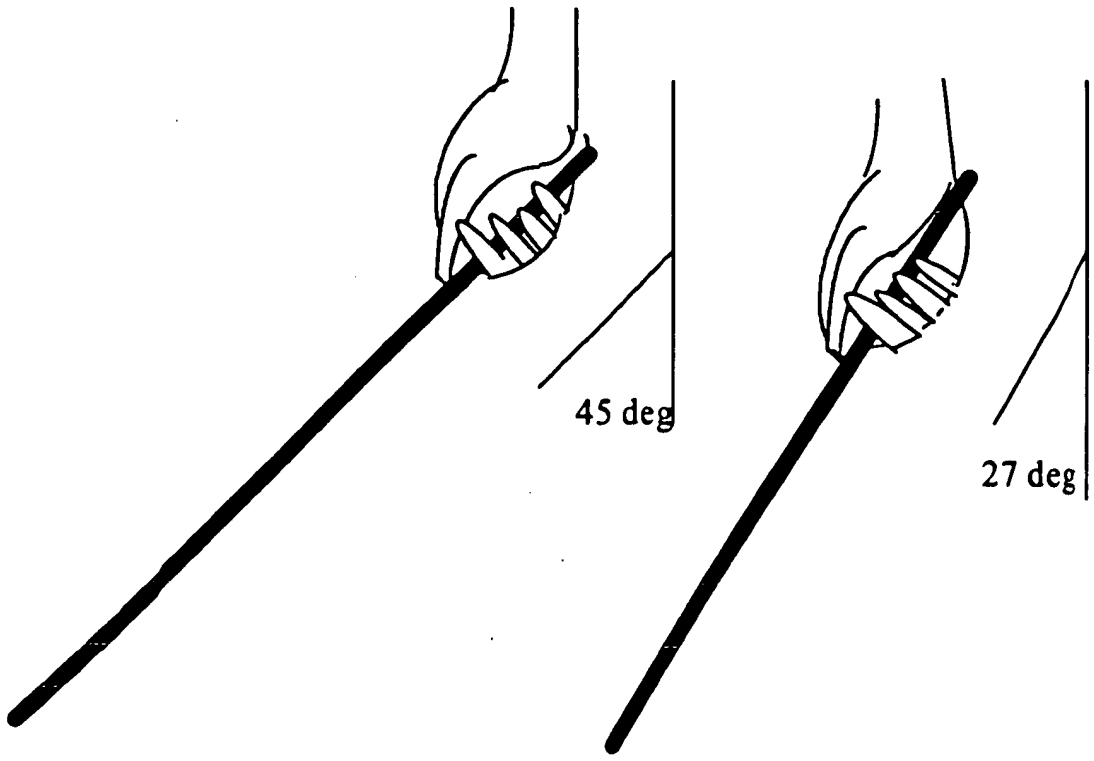
The preceding analysis provides the groundwork for the approach to a new set of design concepts for the new longer lighter wood clubs. The preservation of wood lie angles which are higher than the general population requires shows that higher lie angles are what are required to optimize performance of the wood clubs. Measurements of the effects of increases in club shaft length have shown that the longer the club, the greater the tendency to mis-hit the ball. These mis-hits occur in an ellipse whose centerline is perpendicular to the centerline of the club shaft.. As long as the lie angle of the shaft is fixed at, say 54 degrees, then as the length of the club is increased to take advantage of the new technology, there will be a tendency for the impact point of the ball to move perpendicular to the shaft, and up off the face.

To solve this problem, the following approach is proposed. Abandon the classic standard lie angle, (which has been shown to be incorrect for woods in any event), and design the wood club with a shaft lie angle such that a line perpendicular to the shaft centerline passes through the center of the face, at the sweet spot. This perpendicular will extend near the point of intersection of the shaft with the heel of the sole, and then near the top of the face at the toe line. Thus, the club head should be designed so that the peripheral weighting is concentrated in the sole heel area and at the toe at the top of the face. This will provide the best peripheral weighting, based on the fact that the mis-hits will occur in the ellipse with a centerline along the line perpendicular to the shaft, not with an impact ellipse with a horizontal centerline.

For a driver with a standard lie of 54 degrees, the centerline of this distribution is about 36 degrees above the horizontal, and can move off the top of the face as described above. This will result in the impact ellipse moving up off the face of the driver as the driver length is increased. The reason for this can be seen in the following diagrams. The optimum address position for the golfer's arms is to position the arms as close to vertical as possible, which minimizes any arm motion towards or away from the golfer's body. The club then sets up with the angles shown in the diagram for a golfer with the average club butt height of 32 inches. It is easier for the golfer to hold the hand and wrist angle for the wedge than it is for the driver, since centrifugal force will tend to pull the shaft and head down towards the vertical. As the driver length increases, this effect becomes even more pronounced, as shown in the Golfsmith data. In order to minimize the mis-hits, the lie angle of the driver should be increased. This lie angle is optimized when the perpendicular to the shaft centerline passes through the sweet spot on the face of the driver, forcing the impact ellipse to stay as much as possible on the face. This lie angle depends on the design of the driver club head, which should be optimized by a radiused sole, and a head weighting that is low in the heel and high in the toe of the club head. Estimates for this optimum lie angle are in the range of 62 to 68 degrees, which will result in the perpendicular to the shaft to be 22 to 28 degrees above the horizontal. If the impact ellipse has a horizontal dimension of 3 inches, this would correspond to a vertical dimension of about 1 to 1.3 inches. This would keep the majority of the area of the impact ellipse on the face of an oversized driver, which would be about 3.5 inches long, and about 2 inches deep.



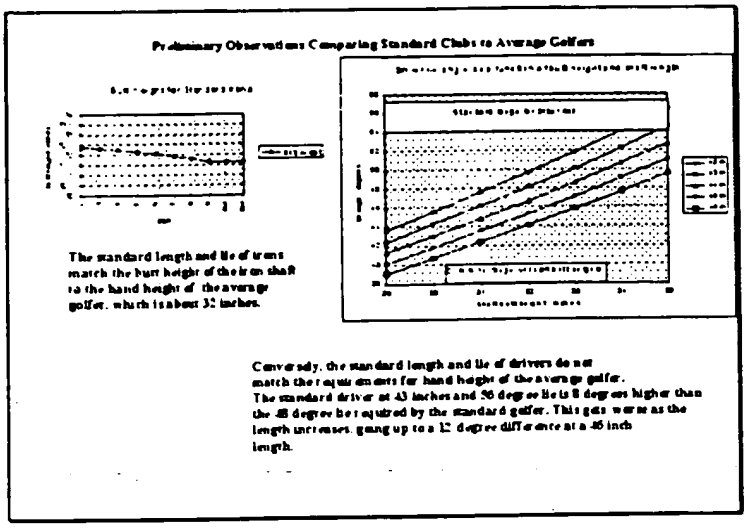
This photograph, circa 1930, shows Jim Reynolds, the long driving champion at that time, in the GE laboratory where his swing is being analyzed. The points to note are the vertical position of his arms, and the lie angle that he has set up with his driver. The orange vertical line is closely the same length as the orange horizontal line. This indicates that the lie angle he has established is 45 degrees. His strong Vardon overlapping grip locks the club into its position behind the ball, and must be held throughout the swing to assure good ball contact. The driver head is in a toe-up position at address, due to the fact that Reynold's 45 degree lie angle at address is lower than the 54 degree lie built into the driver. So even nearly seventy years ago, the same situation with wood lies occurred as it does at the present time. If his hand and wrist position were pulled down by centrifugal force during the swing, the result would be a counterclockwise rotation of the shaft and head, and the movement of the impact point of the ball off the top of the club head. The vertical position of his arms minimizes any linear movement towards or away from his body. The major movement that would cause a mis-hit is a rotation of his hands and wrist. This graphically illustrates the analysis discussed above.



Driver Wedge

The following photograph of a skilled golfer further illustrated these concepts.

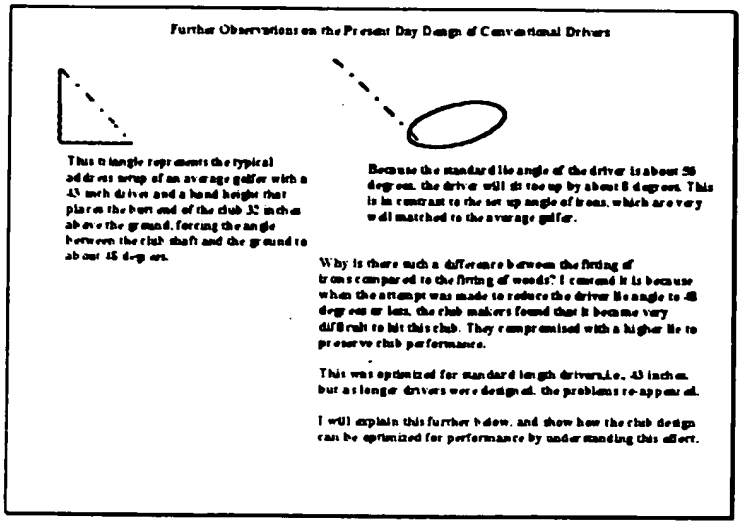
Slide 2



This slide shows a plot of standard length and lie of irons and how this matches the butt height of the iron shaft to the hand height of the average golfer, which is about 32 inches.

Conversely, in the second plot, the standard length and lie of drivers do not match the requirements for hand height of the average golfer. The standard driver at 43 inches and 56 degree lie is 8 degrees higher than the 48 degree lie required by the standard golfer. This gets worse as the length increases, going up to a 12 degree difference at a 46 inch length.

Slide 3



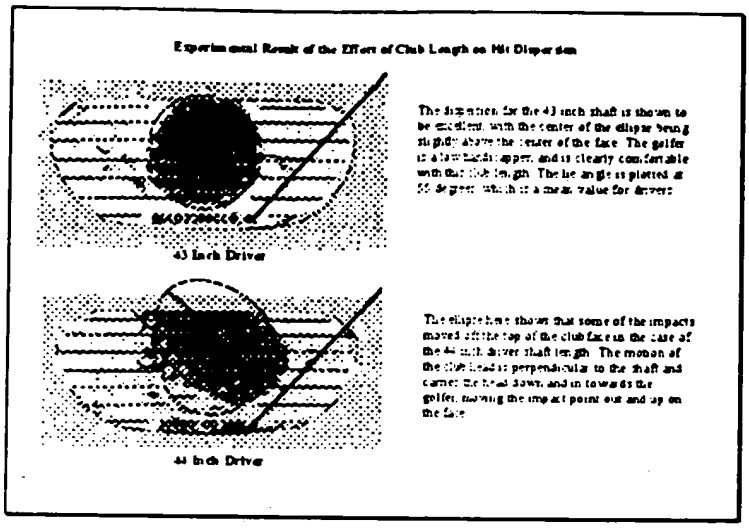
The diagrams show the setup angles for typical players. The triangle represents the typical address setup of an average golfer with a 43 inch driver and a hand height that places the butt end of the club 32 inches above the ground, forcing the angle between the club shaft and the ground to about 48 degrees.

Because the standard lie angle of the driver is about 56 degrees, the driver will sit toe up by about 8 degrees. This is in contrast to the set up angle of irons, which are very well matched to the average golfer.

Why is there such a difference between the fitting of irons compared to the fitting of woods? I contend it is because when the attempt was made to reduce the driver lie angle to 48 degrees or less, the club makers found that it became very difficult to hit this club. They compromised with a higher lie to preserve club performance.

This was optimized for standard length drivers, i.e., 43 inches, but as longer drivers were designed, the problems re-appeared. I will explain this further below, and show how the club design can be optimized for performance by understanding this effect.

Slide 4



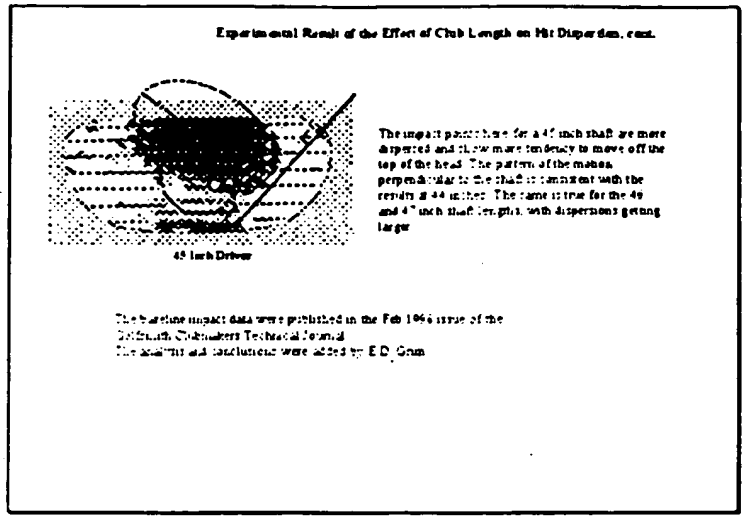
The dispersion for the 43 inch shaft is shown to be excellent, with the center of the ellipse being slightly above the center of the face. The golfer is a low handicapper, and is clearly comfortable with that club length. The lie angle is plotted at 55 degrees, which is a mean value for drivers.

The ellipse here shows that some of the impacts moved off the top of the club face in the case of the 44 inch driver shaft length. The motion of the club head is perpendicular to the shaft and carries the head down, and in towards the golfer, moving the impact point out and up on the face.

The dispersion for the 43 inch shaft is shown to be excellent, with the center of the ellipse being slightly above the center of the face. The golfer is a low handicapper, and is clearly comfortable with this club length. The lie angle is plotted at 55 degrees, which is a mean value for drivers. Also, this shows that the club designers picked a good combination of 56 degrees of lie with a 43 inch driver shaft length.

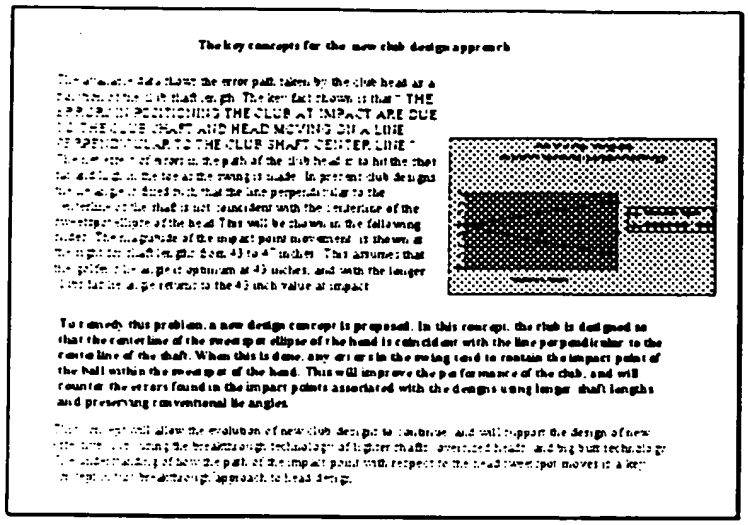
The ellipse on the 44 inch driver shows that some of the impacts moved off the top of the clubface. The motion of the club head is perpendicular to the shaft and carries the head down and in towards the golfer, moving the impact point out and up on the face. This line of motion will also be seen in the following slide.

Slide 5



The impact points here for a 45 inch shaft are more dispersed and show more tendency to move off the top of the head. The pattern of the motion perpendicular to the shaft is consistent with the results at 44 inches. The same is true for the 46 and 47 inch shaft lengths, with dispersions getting larger. These observations lead to the concept for a new club design.

Slide 6

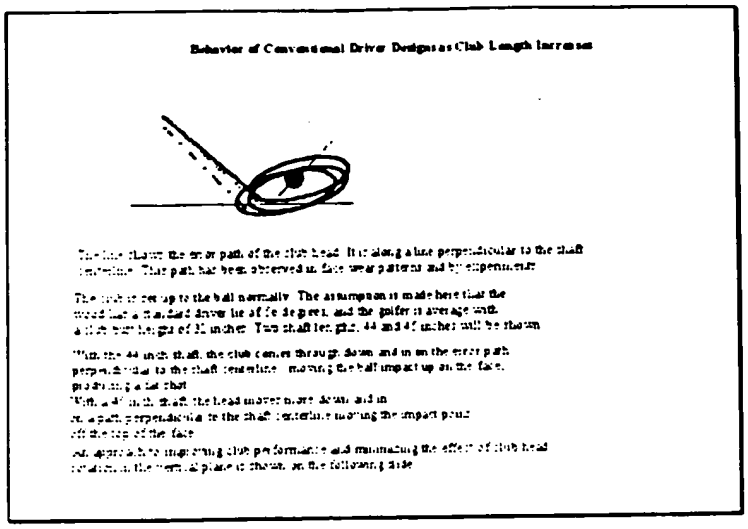


The available data shows the error path taken by the club head as a function of the club shaft length. The key fact shown is that " THE ERRORS IN POSITIONING THE CLUB AT IMPACT ARE DUE TO THE CLUB SHAFT AND HEAD MOVING ON A LINE PERPENDICULAR TO THE CLUB SHAFT CENTER LINE." The net effect of errors in the path of the club head is to hit the shot fat and high in the toe as the swing is made. In present club designs the lie angle is fixed such that the line perpendicular to the centerline of the shaft is not coincident with the centerline of the sweet-spot ellipse of the head This will be shown in the following slides. The magnitude of the impact point movement is shown at the right for shaft lengths from 43 to 4" inches. This assumes that the golfer's lie angle is optimum at 43 inches, and with the longer clubs his lie angle returns to the 43 inch value at impact

To remedy this problem, a new design concept is proposed. In this concept, the club is designed so that the centerline of the sweetspot ellipse of the head is coincident with the line perpendicular to the centerline of the shaft. When this is done, any errors in the swing tend to contain the impact point of the ball within the sweetspot of the head. This will improve the performance of the club, and will counter the errors found in the impact points associated with the designs using longer shaft lengths and preserving conventional lie angles.

This concept will allow the evolution of new club designs to continue, and will support the design of new effective clubs using the breakthrough technology of lighter shafts, oversized heads, and big butt technology. The understanding of how the path of the impact point with respect to the head sweet-spot moves is a key concept in this breakthrough approach to head design

Slide 7



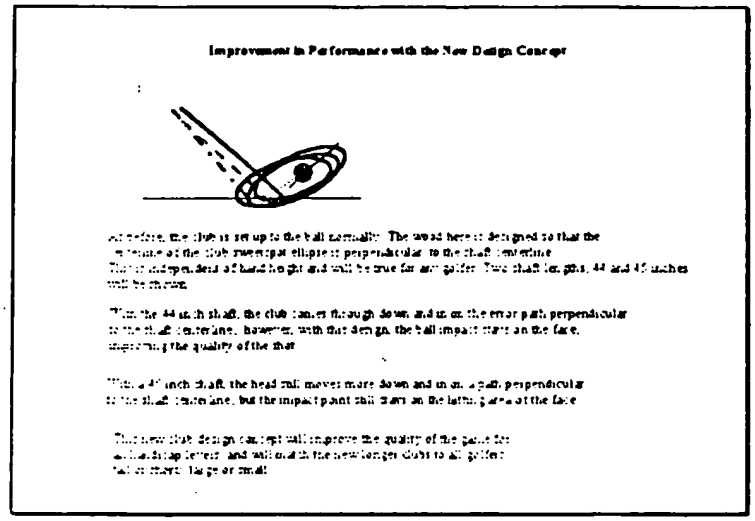
The line perpendicular to the clubshaft centerline shows the error path of the club head. This path has been observed in face wear patterns and by experiments. The green circle is the ball position, which does not change.

The club is set up to the ball normally, shown by the clubpo0-ition on the right. The assumption is made here that the wood has a standard driver lie of 56 degrees, and the golfer is average with a club butt height of 32 inches. Two shaft lengths: 44 and 45 inches are also shown.

With the 44 inch shaft, the club comes through down and in on the error path perpendicular to the shaft centerline: moving the ball impact up on the face, producing a shot that is fat.

With a 45 inch shaft, the head moves more down and in on a path perpendicular to the shaft centerline moving the impact point off the top of the face. The 44 and 45 inch club head positions are shown to the left of the original position. Od the 43 inch clubhead

Slide 8



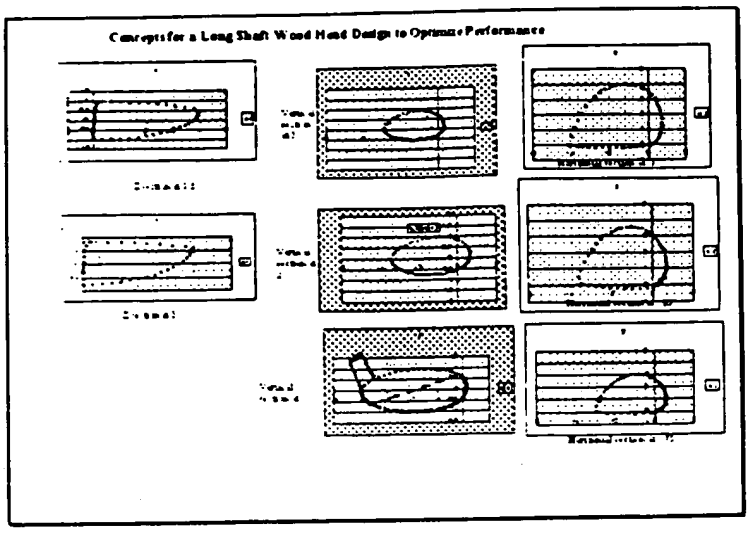
As before, the club is set up to the ball normally. The wood here is designed so that the centerline of the club sweetspot ellipse is perpendicular to the shaft centerline. This is independent of hand height and will be true for any golfer. Two shaft lengths: 44 and 45 inches will be shown.

With the 44 inch shaft, the club comes through down and in on the error path perpendicular to the shaft centerline; however, with this design, the ball impact stays on the face, improving the quality of the shot.

With a 45 inch shaft, the head still moves more down and in on a path perpendicular to the shaft centerline; but the impact point still stays on the hitting area of the face.

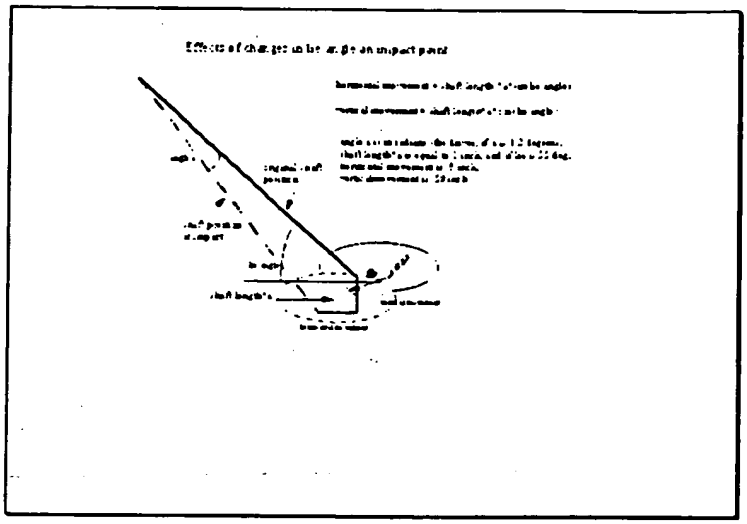
This new club design concept will improve the quality of the game for all handicap levels, and will match the new longer clubs to all golfers tall or short, large or small.

Slide 9



This slide shows some conceptual cross sections for the new club head design. The weighting is towards the toe, and the hosel lie angle is set up to keep the error ellipse centerline aligned with the sweet spot of the club head. This design will improve the quality of the game for all handicap levels, and will match the new longer clubs to all golfers tall or short, large or small..

Slide 10



This diagram is included for reference and shows the head motion resulting from angle changes in the hand position, i.e., small lie angle changes.